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Arizona

Time-of-Use Electricity Price Effects:

Prepared for the U.S. Department of Energy
Office of Utility Systems

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Jerome A. Olson • Bryan Krakauer

MASTER

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ABSTRACT

The Arizona Electric Utility Rate Demonstration project was conducted to observe the effect that time-of-use electricity rates would have on household electricity consumption. Under time-of-use rates higher prices are charged for electricity used during those parts of the day when demand and system costs are higher and lower prices are charged for those parts of the day when demand and system costs are lower. In the Arizona project 140 voluntary households were placed on one of 28 time-of-use electricity rates between May and October 1976. These volunteers were divided into three groups distinguished by the length of the peak rating period (3, 5, and 8 hours).

A comparative analysis of 1975 and 1976 for Group I customers fairly convincingly showed that, as a group, the experimental participants reduced their electricity consumption during the three-hour peak rating period by 7-16 percent. To a lesser extent experimental households reduced consumption during the intermediate period and shifted some consumption to the base period. Total consumption appears to have decreased slightly.

A regression analysis of data from all three groups failed to demonstrate significant elasticities (degree of responsiveness to price) for peak, intermediate, or base prices among test customers; in other words, there were no detectable price-related differences between the consumption patterns of different households that faced alternative time-of-use electricity prices.

The results of the analysis are limited by the experimental and rate designs and are strictly applicable only to portions of the residential populations of Phoenix and Yuma.

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CHAPTER 1: INTRODUCTION

In 1975 the Federal Energy Administration (now part of the U.S. Department of Energy) initiated experiments in ten states to determine how household consumption of electricity is affected by time-of-use pricing.* Funding for the projects was provided by the Federal Energy Administration, participating utilities, and state governments. In the fall of 1977 the Department of Energy (DOE) contracted with the Research Triangle Institute (RTI) to perform a comprehensive, standardized analysis on the data from the residential components of these studies. This report on the Arizona Electric Utility Demonstration Project is one of a series of final reports which will be published under this contract. (For a listing of these reports and a summary of the standardized analytical approach, see the RTI Analytical Master Plan [RTI, 1978].)

1.1 Objectives and Application of Findings

The objectives of the analysis reported here are twofold:

1. to determine whether residential customers on time-of-use rates use significantly more or less electricity during specific hours of the day than customers on conventional rates, and

2. to determine price elasticities of demand for electricity by time-of-day; that is, to determine whether electricity consumption varies among customers who face different time-of-use prices within the peak rating period and similarly, for the intermediate and base periods.

The achievement of these objectives will make a contribution of fact to the growing debate on the effects of time-of-use (TOU) prices and will aid utility planners and regulators in determining rates and in forecasting

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*These ten projects were in Arizona, Arkansas, Connecticut, California (Los Angeles), New Jersey, Ohio, Wisconsin, Vermont, Michigan, and New York. Subsequently, six projects were added in California, North Carolina, Oklahoma (Edmond), Puerto Rico, Rhode Island, and Washington.

electricity demand. For example, in realizing the first objective, we will be providing information on how electricity demand shifts under TOU rates as compared with demand under conventional rates. Similarly, knowledge of elasticities will permit more accurate projection of the effects of varying TOU rate schedules on revenues and on the crude shape of load curves.

1.2 Summary Description of the Experimental Project

Initiated in 1975, the Arizona Electric Utility Demonstration project involved experimental evaluations of time-of-use (TOU) rates both alone and in combination with load control devices or special educational efforts by the staff of the participating utility, the Arizona Public Service Company (APS). Summarized in table 1-1, the portion of the Arizona project analyzed in this report involved TOU rates alone.

Three groups of experimental TOU rates were offered on an annual basis to randomly selected, volunteer residential customers in the Yuma and Phoenix metropolitan areas. These two areas account for most of the summer peaking on the APS system. The volunteer customers were required to have their baseline electricity usage metered by time-of-use between May and October of 1975 while they remained on the conventional APS residential rate. Then, during May-October 1976, all participants were billed under TOU rates. The rate schedules were adjusted, though, to ensure that no household paid more than its previous year's bill. Rather, if a household's total usage and time pattern of usage was identical to that of corresponding months of the previous year, the customer was assured of a bill 30 percent lower than under the prevailing conventional rate. Any divergence from each household's previous year's usage within each of the three daily rating periods was billed or credited at the variable KWH charges specified by one of the 28 unique TOU rates (see table 1-2).

Table 1-1. Summary Characteristics of the Arizona Electric Utility Demonstration Project

1. Participating Agencies/Utilities: U.S. Department of Energy (DOE), Arizona Public Service Company (APS), Arizona Solar Research Commission, Dynamic Sciences, Inc.

2. Type of Study: voluntary, before/after monitoring.

3. Study Period: baseline period, six months, May 1975 to October 1975; test period, six months, May 1976 to October 1976.

4. Metering: three register monthly cumulating meters.

5. Rates: 28 residential time-of-use (TOU) rates with three daily rating periods--peak (P), intermediate (I), base(B). Sixteen Group I rates, 6 Group II rates, and 6 Group III rates where the number of hours in the P, I, and B periods are, respectively, 3-10-11 (I), 5-8-11 (II), and 8-5-11 (III).

6. Number of Customers: 140 customers on TOU rates only; 80 in Group I; 30 in Group II; and 30 in Group III.

7. Incentives/Revenue Neutralizers: individual bill adjustments to achieve monthly credits equal to 20 percent of "estimated bills" under conventional rates.

Five customers were placed on each of the 28 rates, thus a total of 140 volunteers were involved. Of these 28 rates the 16 Group I rates incorporated a three-hour peak period; the 6 Group II rates, a five-hour peak period; and the 6 Group III rates, an eight-hour peak period. Since the same thirteen clock hours (9:00 a.m. to 10:00 p.m.) were covered by both the peak and intermediate periods for all three groups, the lengths of the intermediate periods were 10, 8, and 5 hours for Groups I, II, and III, respectively. All other hours were designated as base hours.

The 140 participants in the experiment were among those eventually retained from simple random presamples of the Phoenix and Yuma service areas. At the time the presamples were selected, the Phoenix and Yuma service areas contained 165,000 and 16,000 qualified (summer-peaking)

Table 1-2. Experimental Rates and Participant Allocation

Rate Number	Rate (cents/KWH)* Peak	Int.	Base	Final Number of Observations† May	June	July	Aug.	Sept.	Oct.	Jul-Sept.
Group I										
1	16	5	3	4	5	5	5	5	3	5
2	15	4	2	3	2	2	3	3	2	2
3	15	7	4	3	3	2	2	2	1	1
4	14	4	2	5	5	5	5	5	5	5
5	14	6	4	5	3	5	5	5	4	5
6	13	3	3	4	5	4	4	4	5	4
7	13	4	2	3	5	5	4	5	4	4
8	13	7	3	4	4	4	4	4	4	4
9	12	5	1	4	4	3	3	3	3	3
10	12	6	3	5	5	5	4	5	5	4
11	11	4	2	3	3	2	2	3	3	2
12	11	7	4	4	3	3	4	4	4	3
13	10	4	1	4	5	3	4	4	4	3
14	10	6	3	3	4	4	4	4	4	4
15	9	5	2	4	5	4	5	4	4	3
16	8	4	1	4	4	4	3	3	3	3
Total				62	65	60	61	63	58	55
Group II										
17	12	4	2	2	3	4	4	3	4	3
18	12	6	4	2	2	3	3	3	4	3
19	11	4	2	4	4	4	4	4	4	4
20	10	6	3	5	5	4	4	3	4	2
21	9	4	2	4	3	4	3	3	4	3
22	6	4	1	3	3	3	3	3	3	3
Total				20	20	22	21	19	23	18
Group III										
23	9	4	2	4	4	4	4	4	4	4
24	8	3	2	4	5	5	5	5	4	5
25	7	4	2	3	4	4	4	4	3	4
26	6	3	1	4	4	4	4	4	4	4
27	5	4	3	5	5	5	5	5	5	5
28	4	3	1	5	5	5	5	5	5	5
Total				25	27	27	27	27	25	27

*Daily rate profiles for each group are diagrammed in figure 2-1.

†Prior to editing by RTI, there were 5 participants per rate. Details of the editing are given in section 2.4 and summarized in table 2-2.

households respectively, or about 63 percent of the total 286,000 residential accounts in the APS system. A substantial number (68 percent) of those in the presample were rejected--some because their billing histories were shorter than one year and some because of inaccessible service entrances, insufficient space to accommodate the TOU meter, or incompatibile wiring for the TOU meters. Due to these restrictions, the results presented in this report, strictly speaking, apply only to those Phoenix and Yuma residential customers who (a) would have volunteered for the study and (b) would not have been excluded for the above reasons. Thus the nature of the sample finally selected for the Arizona project limits the population to which these results can be projected accurately.

For various reasons, including both customer billing under a default scheme (which prevented bills larger than they would have been under the prevailing conventional rates) and the absence of appropriate demographic data, the sample was further pared through editing at the time of analysis to about 70 percent of its original size depending on the particular month(s) and group of customers involved (see table 1-2).

1.3 Summary of Findings

The results of two types of analyses are included in this report. The first analysis, a comparative analysis, was made to determine whether time-of-use rates, as compared with conventional rates, created a difference in household consumption of electricity. The second analysis, a regression analysis, was made to estimate demand elasticities--measures of changes in the consumption of electricity caused by changes in time-of-use prices.

The comparative analysis was completed for customers in Group I--the group that in both 1975 and 1976 had identical lengths of time in the peak, intermediate, and base periods (late afternoon, morning and evening, and night). This analysis fairly convincingly showed that when on time-of-use rates, the customers in Group I reduced their electricity consumption during the peak rating period by 7-16 percent and the intermediate period by 1-9 percent.* To a less significant degree there is evidence that some of this electricity consumption was shifted to the base period and that overall electricity consumption declined slightly.

These results are presented graphically in the four panels of figure 1-1, which show monthly weather-adjusted average daily KWH usage for each of the three daily rating periods for 1975 and 1976, together with average total daily KWH usage. The charts reflect both the 7 to 16 percent reductions in peak period KWH usage from June to October and the reductions in intermediate period usage in each of the months. Finally, the lack of statistical significance in either the average increase in base period consumption or in the average decrease in overall electricity consumption is apparent from the small between-year differences shown in the last two panels of figure 1-1.

By contrast the regression analysis failed to detect any significant price elasticities for peak, intermediate, or base period consumption; that is, there was no significant change in KWH consumption as time-of-use prices were varied. An alternative approach to the demand analysis is reported in Appendix D. This alternative more formally integrates economic theory in the form of more restrictive estimation models than those of chapter 4. The overall conclusion is that the apparent statistical significance of price effects in those models was very questionable and probably a direct result of untested restrictions incorporated in the estimation models. For the

*As detailed in chapter 3, this conclusion follows even after adjustments for differences in weather conditions during the two years.

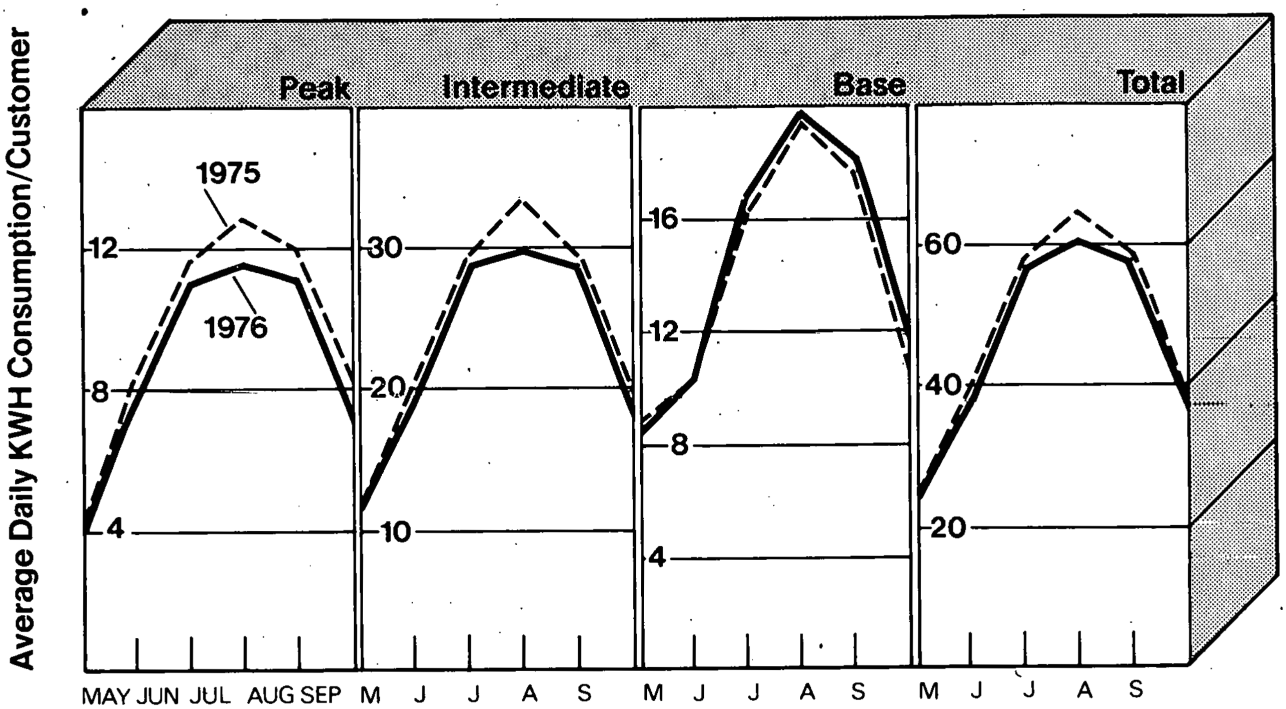


Figure 1-1. Comparison of Weather Adjusted 1975 and 1976 Average Daily KWH Electricity Usage of Group I Customers

more straightforward TOU electricity demand models of chapter 4, elasticities for peak, intermediate, and base periods were essentially zero. For these models, the few cases in which particular "significant" elasticities appeared may have been spurious.

While there may have been many reasons for observing a decrease in peak and intermediate consumption and zero elasticity for peak, intermediate, and base prices, one possible explanation is the substantial emphasis that the billing scheme, as conveyed in the customer education literature, placed on the discount formula and its association with peak, intermediate, and base times of the day, as opposed to the exact cost of peak, intermediate or base KWH.

Thus for the study as a whole, the overall conclusions are:

1. The customers who participated in the Arizona experiment and whose electricity consumption could be compared both before and after the imposition of time-of-use rates did reduce their electricity consumption during the peak period by 7-16 percent and during the intermediate period by 1-9 percent. Some of the reduction may have been shifted to the base period and overall electricity consumption declined slightly.

2. No statistically significant price elasticities were observed for time-of-use prices; that is, the time-of-use pattern of electricity consumption by participants in the experiment did not vary with the time-of-use pattern of peak electricity prices. However, the proper interpretation of this finding is confused by the complexities of the Arizona study design.

1.4 Limitations of the Demonstration and Qualification of Analytical Results

One serious limitation on the scope of this study is caused by the highly restricted subset of the APS population to which the results of this analysis pertain. To qualify for participation in the demonstration households had to be located in Phoenix or Yuma, be summer peaking, and have more than one year's billing history. In addition, many households actually chosen for participation had to be rejected because of difficulties in installing or servicing the TOU meter. Finally, all households had the right to refuse to participate in the study. As a result, it was estimated that only about 19 percent (54,750) of the total number of APS residential households (286,000) were qualified to participate.

A second major limitation is the manner in which electricity bills were calculated. Bills were computed in such a way that an average customer would save 30 percent off the prevailing conventional rate, even if his usage remained unchanged from the previous (baseline) year. Furthermore, all bills were constrained to be no larger than what they were during the baseline year, regardless of how much additional electricity was consumed. It is quite likely that this billing procedure removed a sizeable proportion of the average customer's incentive to reshape his electricity consumption patterns in a manner compatible with his time-of-use pricing schedule.

The effects of other qualifications on the results are probably minor compared to those of the two problems just described. They may be summarized briefly as follows:

- The results apply only to the months May to October.

- The sample size of 140 is small when one considers that there were 3 separate analysis groups and a total of 28 different TOU rates. Even when demographic differences among customers are controlled, variability among electricity consumption patterns of the households in the sample may be so great as to obscure any real responses to the experimental rates.

- About 30 percent of the 140 households in the original sample had to to be edited out of the sample due to bad or missing data. It is unknown to what extent this affected the characterisitcs of the population to which inferences can be drawn. However, this is of lesser concern because the original exclusion criteria had by this time made the population of inference quite small and obscurely defined.

- The numbers of Phoenix and Yuma residents in the presample from which the final list of participants was selected reflected a higher sampling rate of the Yuma population (roughly five times greater than that of Phoenix). Since these two lists of Phoenix and Yuma residents were random samples, a weighted analysis would be appropriate to correct for the different sampling rates. Unfortunately, as the footnote of table 2-1 points out, a much higher percentage of Yuma residents than Phoenix residents in the presample failed to qualify for inclusion in the experiment. Because the number of customers that failed to qualify was so substantial, it could no longer be assumed that the final groups of participants were random samples, nor could it be assumed that the two groups were equally representative of their respective cities. In light of this, it was decided not to perform a weighted analysis.

- All households placed on the TOU rates were volunteers, i.e., once chosen, they had the right to refuse to be billed under a TOU rate. Those who refused were relegated to the control group and billed under the conventional rate.

- There was no "effective" control group in the experiment. Comparative analyses of the data between the experimental group and the small control group (composed of those customers who refused TOU rates) would be virtually useless. The consumption behavior of those who refused to volunteer (control group) would almost certainly be different from that of those who agreed to participate (experimental group). Thus, these differences could not be attributable just to the fact that the two groups faced different rate structures.

- The usage data are monthly aggregations and therefore the analysis results apply to average demand rather than peak demand.
- The TOU rate schedules may have been confusing to some participants (see section 2.2).

CHAPTER 2: PROJECT CHARACTERISTICS

This chapter describes design characteristics of the Arizona Electric Utility Demonstration Project. The first section summarizes major features of the experiment, including such items as the study period, metering, and the number of customers involved; the second section describes the experimental rates that were applied; the third section summarizes the design of the sample; and the fourth section reviews the data editing procedures employed in the analysis.

2.1 History and Major Features of the Project

The Arizona project was initiated in 1975 under a cooperative agreement between the U.S. Department of Energy, the Arizona Public Service Company (APS), the Arizona Solar Energy Research Commission, and Dynamic Sciences Incorporated. The study involved the evaluation of both residential time-of-use (TOU) rates alone and TOU rates combined with either load control equipment or continuing interactions with APS staff. The analysis reported here is confined to that portion of the demonstration focusing on TOU rates alone.

A total of 140 randomly selected residential customers in Yuma and Phoenix volunteered to participate in this study. The study began with the collection of baseline data during the six month period from May 1975 to October 1975. These baseline data were collected for comparison with customer responses during the TOU rate test period. The test data were collected from May through October 1976, using three-register monthly cumulating meters that were set to record usage for the three daily rating periods that were eventually applied to 80 (Group I) of the 140 customers on TOU rates. The summer test period was of obvious interest to APS because it is a strong summer-peaking utility. A single questionnaire was administered twice prior to the TOU rate test period (May to October, 1976) and once again at the end of that period.*

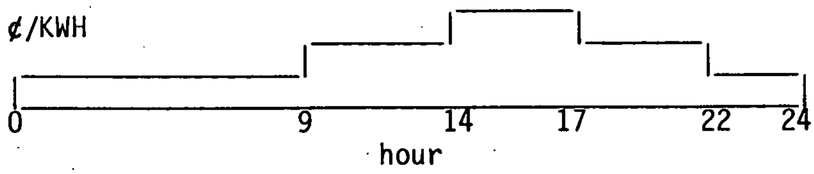
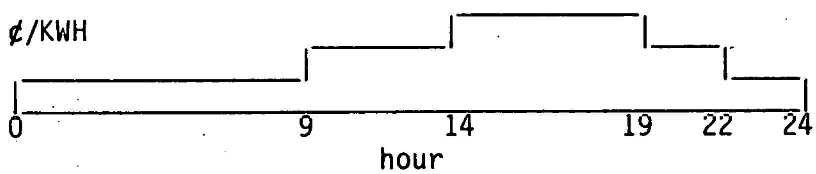
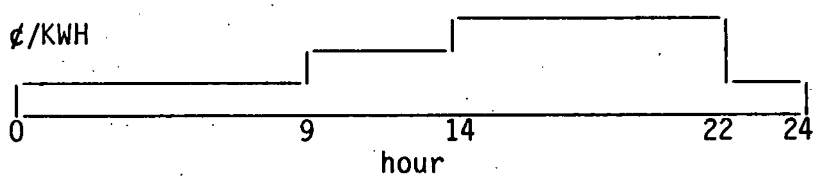
2.2 Design of the Experimental Rates

The twenty-eight TOU rates were divided into three groups distinguished by the length and start-time of the peak and intermediate rating periods. Table 1-2 shows the three groups and the distribution of rates and experimental households among them. Group I had a 3-hour peak period (2-5 p.m.) and contained 16 rates that had peak to base marginal price ratios ranging from 8:1 to 2.75:1; Group II had a 5-hour peak period (2-7 p.m.) and contained 6 rates with marginal price ratios ranging from 6:1 to 3:1; and Group III had an 8-hour peak period (2-10 p.m.) and contained 6 rates with marginal price ratios ranging from 6:1 to 1.67:1. Figure 2-1 shows the daily profiles of those rates which were applied on all days (weekends and holidays as well as weekdays) during the six month experimental period.

The design of the TOU rates in Arizona involved a unique scheme for giving experimental customers credits on their electric bills. The scheme was designed with two purposes in mind: (1) to permit substantial variation in the marginal time-of-day price of electricity, that is, the peak, intermediate or base price, and (2) to provide the volunteer customers with a financial incentive to participate in the experiment. The credits resulted in 1976 monthly bills that were about 30 percent lower than they otherwise would have been if each customer had used the same amount of electricity in a given time period in 1976 as he had used in that time period in

*Copies of the pre- and post-test interviews are given in section V of Appendix B to the Arizona project final report (Arizona Solar Energy Research Commission, 1977).

Figure 2-1. Schematic of Arizona Experimental Rates

Daily Rate Profiles*	Number of Rates†	Effective Periods: months	Effective Periods: days
Group I: 	16	all	all
Group II: 	6	all	all
Group III: 	6	all	all

*Hour zero (0) on the rate profile refers to 12:00 midnight.

†In this context a "rate" refers to a particular combination of peak, intermediate, and base prices.

1975.* This bill reduction was achieved through the combined effects of two features of the rate schedule:

1. omission of the 12 percent general rate increase of April 1976 from the rate charged the test groups, and

2. adjustment of individual monthly bills through a "base KWH" allowance system. For each customer a "base KWH" was computed for each rating period. The allowance was equivalent to 120 percent of last year's KWH consumption in that time period for a given billing

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*For each month of the test year, a "base energy" level, KWH_{bi}, is computed for each rating period based on consumption, KWH_{0i} in the same month of the base year (these were estimated for the Group II and Group III customers):

$$KWH_{bi} = KWH_{0i} + .2\ KWH_{0i} \frac{P_0}{P_i}.$$

The bill, B_1, for each month of the test year is figured as:

$$B_1 = B_0 + \sum_{i=1}^{3} P_i\ (KWH_{1i} - KWH_{bi}), \text{ where}$$

B_0 = previous year's bill,

P_i = test year price by TOU, i = base, intermediate, peak,

KWH_{1i} = test year usage by TOU, i = base, intermediate, peak, and

$P_0 = \frac{B_0}{KWH_0}$ = average energy price in base year (1975), where

$KWH_0 = \sum_{i=1}^{3} KWH_{0i}$ = previous year's total usage.

This reduces to:

$$B_1 = .8\ B_0 + \sum_{i=1}^{3} P_i\ (KWH_{1i} - KWH_{0i}),$$

i.e., the 1976 bill equals 80 percent of the 1975 bill plus the difference between the energy charges for 1976 usage at TOU prices and 1975 usage at TOU prices. Therefore, the marginal cost of energy is simply P_i; this may be seen by taking the derivative of B_1 with respect to KWH_{1i}.

Also, since B_0 was about 88 percent of what a customer's bill, B^*, would have been on the conventional rate in 1976, no change in usage would have been billed at $B_1 = (.8)(.88)B^* = .704\ B^*$ which implies a combined bill reduction of 29.6% for customers that used exactly the same amount of electricity in each of the three rating periods during both 1975 and 1976.

month. If a customer had used his base amounts, his bill would have been about 20 percent lower than his 1975 bill. Because the conventional rates were raised in 1976, this bill reduction would have been about 30 percent of his bill under those rates.

In addition, constraints were placed on each household's bill so it could be no less than 30 percent and no more than 100 percent of the amount that would have been paid on the conventional rate in effect during 1976. Had these constraints not been in effect, about 7 to 10 percent of the volunteers would have been billed more under the TOU rates than under the conventional rates.*

2.3 Design of the Sample

The metropolitan areas chosen for sampling were Phoenix and Yuma, the two regions largely responsible for summer peaking on the APS system. They contained about 63 percent of the APS residential accounts--181,000 of the 286,000 APS residential customers--at the time the sample was selected. From these accounts simple random presamples of 414 Phoenix customers and 210 Yuma customers were drawn.

Of those customers selected in the Phoenix presample, 18 percent were rejected because they had billing histories of less than one year and 41 percent were rejected because of inaccessible service entrances or because of insufficient space to accommodate the TOU meter. Thus, exclusions in Phoenix totaled 59 percent, leaving only 41 percent of the presampled population eligible to be sampled. In Yuma, exclusions left eligible only 14 percent of its presampled population. A total of 183 customers from Phoenix and Yuma were assigned to the time-of-day and load control experimental rates. Of these customers, 140 were assigned to the 28 experimental groups

*This appeared most common for 1976 vacationers who had established very high "base KWH" (and hence discounts) in 1975.

Table 2-1. Criteria for Inclusion in the Demonstration

Inclusion Criterion	Percent Included	Number of Customers
(1) Residential APS customer	100%	286,000
(2) Summer-peaking customer	70% of (1)	200,000
(3) Resident of Phoenix or Yuma	90% of (2)	181,000
(4) More than one year's billing history	87% of (3)	156,750
(5) Accessible service entrance, sufficient space for the TOU meter, and compatible wiring for the meter	37% of (4)*	58,000
(6) Customer willing to participate	94% of (5)	54,750

*The inclusion percentages for this criterion differ substantially between Phoenix and Yuma. They are 50% for Phoenix and 15% for Yuma.

of 5 customers each (see table 1-2) in Groups I-III, and 11 customers were assigned to the "control" group for the time-of-day experiments.

Two features of the Arizona sample severely limit the population to which analytical results can be projected. First, the experimental rates in the Arizona study were offered on a voluntary basis. Secondly, only 26 percent of the Phoenix, and 9 percent of the Yuma APS residential customers were actually given a chance to be selected as a volunteer. A detailed accounting of the effects of criteria used to determine qualification for participation in the study is given in table 2-1.

Since the "control" group was largely composed of customers who refused to accept an experimental rate no effective control group was actually monitored. For further details on the design of the Arizona sample refer to Volume II of the Analytical Master Plan (RTI, 1978) and to Hill, et al. (1978).

2.4 Editing of Sample Data

Table 2-2 summarizes, by month, deletions due to editing that were made prior to the analysis of the 1976 test data. These deletions reduced the original sample to roughly 70 percent of the original totals. It was this edited sample that was used in the analyses. There were five major reasons for excluding customers: 1) a customer had zero or near zero usage in the test period because of the occurrence of some anomalous event, perhaps a vacation; 2) demographic data were unavailable; 3) a household was actually billed on the conventional rate (zero discount) as described above; 4) income data were unavailable; and 5) a change in home ownership had occurred during the study.

The total number of excluded households and the resulting total number of observations for each month are also reported in table 2-2. The last column of the table gives corresponding information for the aggregated data from the months July through September, since these data were used to represent the "core" months of the summer season in several of the reported regressions. Appendix A contains the supporting details for this table for each of the 140 individual customers, identified by their experiment ID codes.

Appendix B provides a detailed summary of the data processing procedures for file creation and analysis that were applied in completing the regressions together with additional information on editing.

Table 2-2. Summary - Edits of Sample

Reason	May	June	July	August	September	October	Jul-Sep
Group I:							
Zero or near zero usage	1	0	2	3	3	3	4
No demo. file	2	2	2	2	2	2	2
Zero discount	8	6	8	7	5	11	11
Income not reported	5	5	5	5	5	5	5
Change in home owner	4	4	4	4	4	4	4
Other	1	0	1	3	3	2	3
Total Exclusions*	18	15	20	19	17	22	26
Total Observations	62	65	60	61	63	58	55
Group II:							
Zero or near zero usage	0	0	0	0	1	0	1
No demo. file	0	0	0	0	0	0	0
Zero discount	4	4	2	2	3	2	4
Income not reported	2	2	2	2	2	2	2
Change in home owner	4	4	4	4	4	4	4
Other	0	0	1	1	1	0	1
Total Exclusions*	10	10	9	9	11	7	12
Total Observations	20	20	21	21	19	23	18
Group III:							
Zero or near zero usage	1	1	1	1	1	1	1
No demo. file	1	1	1	1	1	1	1
Zero discount	2	0	0	0	0	2	0
Income not reported	2	2	2	2	2	2	2
Change in home owner	1	1	1	1	1	1	1
Other	0	0	0	0	0	0	0
Total Exclusions*	5	3	3	3	3	5	3
Total Observations	25	27	27	27	27	25	27

*Columns are not additive because a given user may fall into more than one exclusion category.

The editing included a significant effort by both the APS and RTI staff to correct the Arizona data base that had been used in previous studies of the Arizona data, e.g., Taylor (1978). The original reported data were the actual KWH consumption meter readings for each customer's billing months which differed among customers by as much as 22 days, e.g., during the June 1976 billing month one customers's meter readings reflected 22 days of usage and another's represented 44 days of usage. Therefore it was apparent that previous attempts to explain variation in <u>total</u> KWH consumption within daily rating periods for each billing month had been impeded by the failure to adjust the data to account for this source of variation. The analysis reported here relies upon the actual meter-read dates, provided by APS, to compute actual average daily KWH usage in each of the daily rating periods and to use those as the dependent variables in the analysis. Therefore the dependent variables represent billing month averages rather than calendar month averages. Thus, the "monthly" analyses that follow are actually analyses of billing months which differ among customers. To control for these differences, variables reflecting the average temperature and the number of weekend days and holidays in each customer's billing month were included in the analysis.

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CHAPTER 3: COMPARATIVE ANALYSIS

This chapter presents comparisons between 1975 and 1976 average daily electricity consumption during each of the three daily rating periods (peak, intermediate and base) for Group I customers in the Arizona study (figure 2-1). The results can be projected only to those Yuma and Phoenix customers who would have volunteered to participate in the experiment and would not have been excluded for the specific reasons described in sections 2.3 and 2.4 above. The overall conclusion developed in this chapter is that Group I customers significantly reduced their electricity consumption during the peak and intermediate periods. The evidence also suggests, but less convincingly, that Group I customers shifted some of that usage to the base period and reduced their electricity consumption overall.

3.1 Estimation Model

A very basic question about TOU rates is: are electricity consumption patterns for customers on TOU rates different from those of the same customers on conventional declining block rates? In the context of the Arizona study, one can analyze data to answer this question by proceeding conditionally in comparing all customer responses under the 1976 test rates to those under the 1975 conventional rate, regardless of the particular marginal time-of-use electricity price that each customer faced. Since peak, intermediate, and base periods actually monitored during 1975 were identical in length to those eventually assigned to the 80 Group I test customers, these customers serve as their own controls and thus were the only customers who could be candidates for this type of comparative analysis.*

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*The Arizona project team imputed 1975 peak, intermediate, and base consumption values for customers in Groups II and III. This was necessary for developing the "discount formula" for each experimental customer (see chapter 2).

The amount of electricity consumed by individual households during each of the three daily rating periods in 1975 (the year before TOU rates were in effect) reflects the combined effects of many factors including tastes, work schedules, appliance stocks, weather, etc. The proposed regression model hypothesizes that electricity consumption during those same periods of 1976 (the year when TOU rates were in effect) is a linear function of all the same factors that affected 1975 consumption and of the change in weather. Since most of the response to Arizona weather during the summer months is likely to be effected in air conditioning demand, effects of changes in weather are likely to be related to the product of the size of the cooled space and the intensity of the outdoor heat. Therefore the proposed model is

$$y^k_{j,76} = a^k + b^k y^k_{j,75} + c^k(w_{j,76} - w_{j,75}) + e^k_j \qquad (1)$$

for k = 1,...,3 (peak, intermediate, and base)
and j = 1,...,n (customers) where

y^k_{jt} = daily KWH consumption in rating period k during year t,

w_{jt} = cooling requirements measured as the product of average daily cooling degree days in year t and air conditioned square footage,

a^k, b^k, and c^k = regression parameters, and

e^k_{jt} = error.

The weather-adjusted difference, Δy^k_j, between a household's electricity demand under TOU rates and under conventional rates is estimated by subtracting 1975 consumption from both sides of eq. (1) and setting the difference in the weather variables equal to zero, i.e., as

$$\Delta y_j^k = \tilde{a}^k + (\tilde{b}^k - 1)\, y_{j,75}^k \qquad (2)$$

where $\tilde{a}^k$, $\tilde{b}^k$ are the estimated parameters of eq. (1). These estimates are assumed to reflect the effects of TOU rates. Average changes are estimated for the sample by substituting sample means into eq. (2), i.e., by

$$\overline{\Delta y}^k = \tilde{a}^k + (\tilde{b}^k - 1)\, \bar{y}_{75}^k. \qquad (3)$$

3.2 Empirical Results

Two comparative analyses were completed. The first was the weather-adjusted analysis of equation (1) which was estimated for each of the three daily rating periods and total daily usage for each of the six months. The second procedure simply consisted of estimating the differences in the raw consumption means of the rate structures being compared. Both analyses lead to the same basic qualitative conclusions that are outlined at the beginning of this chapter.

Table 3-1 reports the average weather-adjusted differences--the estimated values of $\overline{\Delta y}^k$ of eq. (3)--and their associated t-values. For example, the estimated difference for October between average daily peak period consumption in 1975 and then in 1976 is 1.136 KWH, implying a decline in peak period consumption due to the TOU rates even after adjusting for the fact that in Phoenix and Yuma the late summer of 1976 was slightly cooler than that of 1975.

Table 3-2 reports those average differences as percentages of average total consumption during 1975 (reported in parentheses) within each of the three daily rating periods. Thus, the 1.136 KWH reduction during October 1976 represents 16.13 percent of the average daily peak consumption of 7.04 KWH during October 1975.

Table 3-1. Weather-Adjusted Mean Differences between Average Daily KWH Consumption[1] (1976 Average Minus 1975 Average)

Month	Peak	Intermediate	Base	Total
May (n=65)[2]	-0.012 KWH (-0.04)	-0.021 (-0.04)	-0.115 (-0.30)	-0.168 (-0.16)
June (n=67)	-0.806** (-2.24)	-1.247* (-1.66)	0.071 (0.14)	-1.820* (-1.37)
July (n=63)	-0.831** (-2.06)	-0.364 (-0.43)	0.548 (0.80)	-0.722 (-0.44)
August (n=64)	-1.410*** (-3.08)	-3.068*** (-2.92)	0.053 (0.68)	-4.617** (-2.13)
September (n=66)	-0.993*** (-2.39)	-0.384 (-0.36)	0.725 (0.74)	-0.312 (-0.15)
October (n=61)	-1.136*** (-3.91)	-1.148** (-1.79)	1.048* (1.64)	-0.892 (-0.73)

[1]The t-values associated with the average differences are reported in parentheses. All significance tests are one-tailed tests against alternative hypotheses that the differences are negative for the peak and intermediate periods as well as the total and positive for the base period. A single asterisk (*) denotes significance at the 10 percent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. The total number of observations is n.

[2]A few more customers were included in estimating equation (1) than in estimating the models of chapter 4. This happened because households with missing demographic information had to be deleted from the analysis of chapter 4 but could be retained in this analysis.

It appears that from June to October there were significant reductions in peak period consumption--about 7 to 16 percent. Reductions in intermediate period consumption occurred in all months, but they were less consistent from month to month, and generally smaller than the reductions in the peak period. In the base period, consumption increased in the months of June through October, but in no instance were these increases statistically significant. The combined effect of the responses in the three periods was that total average daily consumption showed consistent, but rather small decreases.

Table 3-2. Weather-Adjusted Differences between 1976 and 1975 Average Daily KWH Consumption as a Percent of 1975 Consumption[1]

Month	Peak	Intermediate	Base	Total
May	-0.32 % (3.86 KWH)	-0.18 (11.76)	-1.27 (9.07)	-0.68 (24.69)
June	-10.15** (7.94)	-6.28* (19.87)	0.67 (10.51)	-4.75* (38.33)
July	-7.28** (11.42)	-1.28 (28.53)	3.39 (16.19)	-1.29 (56.14)
August	-10.98*** (12.84)	-9.09*** (33.75)	0.26 (20.87)	-9.52* (67.46)
September	-8.20*** (12.11)	-1.27 (30.18)	4.36 (16.63	-0.53 (58.93)
October	-16.13*** (7.04)	-5.59** (20.53)	9.76 (10.74)	-2.25 (39.72)

[1]Average daily KWH consumption during 1975 is given in parentheses. All significance tests are one-tailed tests against alternative hypotheses that the differences are negative for the peak and intermediate periods as well as the total and positive for the base period. A single asterisk (*) denotes significance at the 10 percent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level.

The fact that usage patterns during May did not conform to the patterns set by the other months suggests that there may have been a learning period. This is supported by the fact that a customer's monthly bill was accompanied in the first month by a detailed account of how his discount was calculated. Thus, many customers may have "learned" to shift their consumption upon receiving their May 1976 electricity bill.

The fact that total adjusted consumption generally decreased in 1976, combined with the fact that increases in base period consumption were not statistically significant, suggests that while customers rather uniformly reduced their consumption in the peak and intermediate periods (9 a.m. to

Table 3-3. Raw Mean Differences between Average Daily KWH Consumption[1] (1976 Average Minus 1975 Average)

Month	Peak	Intermediate	Base	Total
May (n=65)	0.303 KWH (1.48)	0.256 (0.69)	-0.279 (-0.95)	0.280 (0.37)
June (n=68)	-0.401* (-1.48)	-1.077** (-1.92)	-0.273 (-0.71)	-1.751** (-1.79)
July (n=63)	-0.664* (-1.66)	0.008 (0.01)	0.867* (1.30)	0.211 (0.13)
August (n=64)	-1.343*** (-4.24)	-3.564*** (-4.66)	-1.136 (-1.67)	-6.043*** (-4.00)
September (n=66)	-1.177*** (-3.51)	-1.654** (-1.94)	1.602** (2.22)	-1.229 (-0.81)
October (n=61)	-1.416*** (-4.86)	-2.159*** (-3.56)	1.169** (2.06)	-2.406** (-2.20)

[1]The t-values associated with the average differences are reported in parentheses. All significance tests are one-tailed tests against alternative hypotheses that the differences are negative for the peak and intermediate periods as well as the total and positive for the base period. A single asterisk (*) denotes significance at the 10 percent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. The total number of observations is n.

10 p.m.) they differed in the amount of consumption that they shifted to the base period. Clearly, some customers could not shift the reduction in peak and intermediate consumption to the base period. As an example, those customers who reduced their air conditioning in the daytime might not have been likely to shift this use to the nighttime.

The raw mean differences and percentage differences (unadjusted for changes in cooling degree days) are presented in tables 3-3 and 3-4, which are companions to tables 3-1 and 3-2, respectively. Generally the results conform to the same patterns as reported for the weather-adjusted differences. It is notable that the unadjusted mean differences are most pronounced

Table 3-4. Raw Differences between 1976 and 1975 Average Daily KWH Consumption as a Percent of 1975 Consumption[1]

Month	Peak	Intermediate	Base	Total
May	7.9 % (3.86 KWH)	2.2 (11.76)	-3.1 (9.07)	1.1 (24.69)
June	-5.1* (7.95)	-5.4** (19.91)	2.6 (10.53)	4.6** (38.39)
July	-5.8* (11.42)	0.03 (28.53)	5.4* (16.05)	0.4 (56.00)
August	-11.8*** (12.84)	-11.3*** (33.82)	-6.2 (20.87)	-9.0*** (67.53)
September	-0.7*** (12.11)	-5.5** (30.18)	9.6** (16.63)	-2.1 (58.9)
October	-16.7*** (8.45)	-10.5*** (20.53)	10.9** (10.74)	-6.1** (39.7)

[1]Average daily KWH consumption is given in parentheses. All significance tests are one-tailed tests against alternative hypotheses that the differences are negative for the peak and intermediate periods as well as the total and positive for the base period. A single asterisk (*) denotes significance at the 10 percent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level.

in the later months. This may be partially explained by the fact that it was slightly cooler during these months in 1976 than it was in 1975. On the other hand, the earlier months in 1976 were slightly warmer than those in 1975.

To summarize the comparative analysis, the results rather convincingly show that, as a group, the customers in Group I reduced their electricity consumption during the peak and intermediate rating periods when they went from conventional declining block rates to TOU rates. To a lesser degree there was evidence that some of this electricity consumption was shifted to the base period and that the overall average of daily residential electricity consumption was reduced slightly.

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CHAPTER 4: DEMAND ANALYSIS

The analysis reported in this chapter attempts to discern the responsiveness of residential customers to variations in the marginal price of electricity within each of the three daily rating periods for each of the three rate groups (see chapter 2). The presentation follows very closely the basic modeling and analytical approach that was outlined in the AMP (RTI, 1978, esp. pp. 72-75). Another exploratory analysis which used a more restrictive modeling approach is reported separately in Appendix D, since the results of that analysis are somewhat questionable.

The overall findings reported in this chapter are pessimistic about the effects of variations in marginal TOU prices as defined in the Arizona study. Specifically, even though the estimated regression models generally explained a substantial amount (usually more than 60 percent) of the variation in time-of-use KWH usage among customers in the experiment, virtually all of that explanatory power was attributable to associated variations in income and demographic characteristics. Almost uniformly, differences in variable KWH prices failed to account in any significant way for differences in TOU electricity consumption. These results could have been caused by the numerous design compromises that were inherent in the Arizona study. Among them were both the relatively small sample sizes (which would have prevented us from detecting small price effects even if they were present) and to the confusing nature of the marginal TOU prices themselves.

The estimation models used in this analysis are defined in section 4.1. Section 4.2 summarizes the empirical results.

4.1 Estimation Model

The alternative estimation models that were developed and applied in the demand analysis are rooted in the theory of consumer demand. The theory assumes that individuals purchase goods and services in quantities that maximize their perceived standard of living, but that their decision making is constrained by the amount of money (income) that is available to them. This fundamental assumption implies a simple mathematical problem of constrained maximization. In other words, by knowing the prices of goods and services and by knowing an individual's income and preferences, "optimum" demands for goods and services can theoretically be determined. These optimum quantities are often referred to in mathematical terms as the solutions to the first order conditions.

Unless one is willing either to specify the mathematical form of the representative individual's "preference function" or to accept in advance certain restrictions on that function,* economic theory implies nothing about the <u>specific</u> functional form of any statistical model used to estimate the demand relationships that are represented by the first order conditions. Rather, economic theory only implies that the optimum quantities are determined by income, prices, and other independent variables that influence individual preferences--e.g., number of children, etc. One approach of applied demand analysis is to estimate a truncated general Taylor's series expansion of these general demand functions implied by economic theory. It is this approach which we have chosen to follow in this chapter as was earlier recommended in our Analytical Master Plan (RTI, 1978). This approach is followed because, while it also incorporates assumptions, the resulting models are generally more straightforward and, therefore, perhaps

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*For example, a common restriction is that the quantities of specific goods and services consumed will not change when all their prices double at the same time that the individual's income doubles.

more appropriate for an initial analysis such as this.* Appendix D reports one of many possible alternative analyses that accept in advance some of the restrictions referred to above.

In this particular application the "optimum" quantities whose variation among households we will attempt to explain are the amounts of electricity consumed during the peak, intermediate, and base periods. Four alternative empirical models were considered as direct approximations of these time-of-day electricity demand functions. In these models variations in time-of-day electricity demand are hypothesized to be functions of variations in prices and several demographic variables that take into account the effect of aggregation over individuals. The four models arise from two different ways of incorporating TOU prices (second-order and first-order) and two different ways of incorporating variations in demographic variables (an explicit set of demographic variables and 1975 usage alone as a portmanteau variable that accounts for taste and habit differences among households). The final models are all stated as double logarithmic functions.† The models are:

$$\begin{aligned}
&\text{MODEL A:} \quad y_t^k = a^k + U^k + V^k + W^k + e^k \\
&\text{MODEL B:} \quad y_t^k = a^k + U^k + V^k + f^k y_{t-1}^k + e^k \\
&\text{MODEL C:} \quad y_t^k = a^k + U^k + W^k + e^k \\
&\text{MODEL D:} \quad y_t^k = a^k + U^k + f^k y_{t-1}^k + e^k
\end{aligned} \qquad (3)$$

*The Analytical Master Plan (chapter 2 and the addendum, RTI, 1978) contains a detailed development of this modeling rationale.

†Linear, semilog, and other specifications were also estimated and evaluated. Generally the double logarithmic models were as good as or superior to the others. Also, share models were estimated and found to generate results similar to those of the reported models.

for k=1,2,3 which refer to the peak, intermediate, and base rating periods, respectively, and t=1976.

where y_t^k = log of average daily KWH consumed in the kth rating period during the billing month(s) of interest during year t,

$U^k = \sum_{i=1}^{3} b_i^k \ln p_i$ = first order price terms,

p_i = marginal price per KWH in rating period i, that is, the peak, intermediate, or base price per KWH,

$V^k = \sum_{i=1}^{3} \sum_{\substack{j=1 \\ j \geq i}}^{3} c_{ij}^k \ln p_i \ln p_j$ = second-order price terms,

$W^k = \sum_{\substack{j=1 \\ j \neq 5}}^{10} d_j^k z_j$ = terms associated with non-price independent variables,

z_j = household-specific independent variables defined in table 4-1 (see W^k above),

$a^k, b_i^k, c_{ij}^k, d_j^k, f^k$ = regression coefficients, and

e^k = error term.

As an example, model A can be written in full (without the k superscripts) as:

$$y_t = a + \sum_{i=1}^{3} b_i \ln p_i + \sum_{i=1}^{3} \sum_{\substack{j=1 \\ j \geq i}}^{3} c_{ij} \ln p_i \ln p_j$$

$$+ d_1(\text{NOHOME}) + d_2(\text{YUMA}) + d_3(\text{LNOHHMEM}) + d_4(\text{LWATT})$$

$$+ d_6(\text{LINCOME}) + d_7(\text{KIDS}) + d_8(\text{LKWH6}) + d_9(\text{LCDD}_6)$$

$$+ d_{10}(\text{LAGEHM}) + e.$$

Actual regression estimates are given in Appendix C. All variables are defined in table 4-1.

Table 4-1. Definitions of Variables

Variable	Definition
Non-price Independent Variables*	
z_1 (NOHOME)	1, if there were more household members than working members, 0, otherwise.
z_2 (YUMA)	1, if the household was located in Yuma, 0, otherwise.
z_3 (LNOHHMEM)	natural logarithm of the number of household members.
z_4 (LWATT)	natural logarithm of the sum of the wattage ratings of household appliances other than air conditioners.
z_5 (AC)	air conditioned square footage, estimated as the square square footage of the home, if it had central air conditioning; and as one plus the reported number of room air conditioners (to account for the fact that at least one room air conditioner in a home is often larger) times the average square footage per room in the house, if it had at least one room air conditioner; otherwise, zero.
z_6 (LINCOME)	natural logarithm of reported gross family income.
z_7 (KIDS)	1, if at least one resident in the household was less than six years old, 0, otherwise.
z_8 (LKWH6)	natural logarithm of the proportion of days in each household's billing month accounted for by weekends and holidays.
z_9 (LCDD6)	cooling requirements, measured as the product of the logarithm of average daily cooling degree days in each customer's billing month and the logarithm of air conditioned square footage, i.e., of z_5.
z_{10} (LAGEHM)	natural logarithm of the age of each customer's home.

*The Statistical Analysis System (SAS) acronyms are given in parentheses.

Table 4-1. (Continued)

Variable	Definition
Price Variables	
LPPA	$\ln p_1$, natural logarithm of peak price.
LPMA	$\ln p_2$, natural logarithm of intermediate price.
LPBA	$\ln p_3$, natural logarithm of base price.
LPP2	$\ln p_1$ squared.
LPM2	$\ln p_2$ squared.
LPB2	$\ln p_3$ squared.
LPPPM	$\ln p_1$ times $\ln p_2$.
LPPPB	$\ln p_1$ times $\ln p_3$.
LPMPB	$\ln p_2$ times $\ln p_3$.
Consumption Variables	
LKWHPEAK, LKWHINTR, LKWHBASE	natural logarithm of the average daily KWH consumption for the 1976 (test year) billing month during the peak, intermediate, and base rating periods, respectively.
LKWHPK5, LKWHIN5, LKWHBS5	natural logarithm of the estimated average daily KWH consumption for the 1975 (baseline year) billing month during the hours of the day assigned to the peak, intermediate, and base rating periods in the following (test) year.

The rationale for models B and D is quite simple. Consumption of electricity during 1975, as much as during 1976, can be regarded as a function of a number of fixed tastes, habits, and requirements in individual households. Thus y_{t-1} can be regarded as a portmanteau variable that represents the collective interactive effects of all those factors and thereby constitutes a reasonable substitute for the W^k terms in models A and C. Correspondingly, a "demographic effects" model, call it model X, can be paired with models B and D and be estimated as

$$\text{MODEL X:} \quad y^k_{t-1} = a^k + W^k + e$$

The income elasticities of demand by time-of-use are directly estimated as the coefficients d^k_6 in models A and C. In models B and D they are estimated as the product $f^k d^k_6$ where the latter coefficient is estimated in model X.

In models C and D the estimates of own- and cross-price elasticities of electricity demand are the direct estimates of the b coefficients, i.e., where n_{ki} is the elasticity of demand for electricity in the kth period with respect to price in the ith period, $n_{ki} = b^k_i$ in models C and D. Consequently the variances of the elasticities are also directly estimated. In models A and B the situation is a little more complicated.

For example, $n_{11} \equiv \dfrac{\partial \ln q_1}{\partial \ln p_1} = b_1 + 2c_{11}\ln p_1 + c_{12}\ln p_2 + c_{13}\ln p_3$ which when evaluated at the sample mean is,

$$n_{11} = b_1 + 2c_{11}p_1' + c_{12}p_2' + c_{13}p_3' \; .$$

Therefore the estimated elasticities at the sample means are linear combinations. Specifically, suppressing the k superscripts and defining

$$B = (b_1\ b_2\ b_3\ c_{11}\ c_{12}\ c_{13}\ c_{22}\ c_{23}\ c_{33})' ,$$

peak period elasticities, $N = (n_{11}\ n_{12}\ n_{13})'$, e.g., are estimated as

$$N = AB \quad \text{where} \tag{1}$$

$$A = \begin{bmatrix} 1 & 0 & 0 & 2p_1' & p_2' & p_3' & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & p_1' & 0 & 2p_2' & p_3' & 0 \\ 0 & 0 & 1 & 0 & 0 & p_1' & 0 & p_2' & 2p_3' \end{bmatrix} .$$

Similar linear combinations apply for the intermediate and base period elasticities. Of course, it also follows that the variance-covariance matrix associated with N is the non-null 3 x 3 matrix

$$s^2A^*(X'X)^{-1}A^{*\prime}$$

where the scalar s^2 is the estimated variance from the regression and A^* is A augmented by an appropriate number of null column vectors to achieve dimensional compatibility with the full design matrix X'.

Since the demand for any good is normally expected to fall when its price rises we would expect all three own-price elasticities to be negative, i.e., that n_{11}, n_{22}, and $n_{33} < 0$. Expectations about cross elasticities are less obvious. If electricity consumed during the peak period is a substitute for that consumed during the intermediate and base periods, then the associated cross-price elasticities should be positive implying, e.g., that an increase in the peak period prices will increase electricity consumption during the base period. (A simple example of substitutes would be tennis shoes and running shoes.) However, it is conceivable that the quantities of electricity consumed during two adjacent time periods are complements, i.e., that an increase in the price of one will reduce the demand for both because they are normally consumed together. (An extreme example of complements would be right and left shoes.) This would, of course, imply negative cross-price elasticities. Unfortunately, though, it is very difficult to predict the conditions under which complementarity will be observed. Overall, it would seem somewhat more likely that quantities of electricity consumed during distinct daily rating periods are substitutes and correspondingly that the cross-elasticities are positive. This prediction is mainly based on the notion that residential electricity consumers do have some flexibility to defer electricity consumption.

4.2 Empirical Results

The regression models of eq. (3) were all estimated with average daily electricity consumption data from the appropriate experimental groups in the Arizona study. Since the population of inference for Yuma and Phoenix were defined by different, but unquantifiable characteristics (see footnote, table 2-1), it was decided that weighted techniques would be of little value. Instead, an indicator variable was used to account for the difference between the sampling rates in the two cities.*

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*It can be argued that weighting should have been applied to adjust for the fairly large number of excluded older homes with incompatible wiring in the original Arizona sample. However, this would be valid only if those older homes with compatible wiring were similar in electricity consumption characteristics to those without--also an arguable presumption.

All four of the regressions of the models given by eq. (3) were estimated for Group I customers. Only models C and D were estimated for Groups II and III customers because only six unique rates were applied to each of those groups; this means that the second-order models A and B are not estimable for those groups (see RTI, 1978, chapter 2). All models were estimated using daily averages for each of the six test months and for the aggregate of the three peak summer months, July through September.

The regressions were generally highly significant with R^2 generally greater than .6. However, the estimates reflected virtually no effects attributable to variations in the <u>marginal</u> TOD electricity prices. Intuitively this means that differences in income and demographic characteristics among households were alone quite successful in explaining variations in electricity usage among households within each daily rating period.* Further, it means that differences in the marginal KWH prices among households added virtually nothing to the explanation of these inter-household variations in electricity consumption.

Table 4-2 gives the results of Chow tests (Chow, 1960) of hypotheses that sets of price coefficients are simultaneously equal to zero for Group I for models A, B, C, and D (i.e., that differences in the marginal KWH prices do not help explain variation in KWH usage among households). Similar tests are reported for Groups II and III for models C and D in table 4-3. The tests denoted as test type 2 report the probabilities of larger values of the F-statistics associated with the restriction that all the second-order price coefficients of eq. (3) are simultaneously zero, i.e., that $V^k = 0$.

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*The most important demographic variables were those derived from the household appliance stock, the number of household members, and the air-conditioned square footage.

Table 4-2. Tests for the Nonsignificance of Marginal Electricity Price Effects: Group I Tests* (Probabilities of Larger F Values)

Model	Regression	Test Type*	Month						
			May	June	July	Aug.	Sept.	Oct.	Jul-Sep
					Group I				
	P	1	.804	.653	.439	.369	.239	.866	.427
		2	.731	.507	.607	.296	.109	.777	.306
A	I	1	.986	.668	.224	.326	.161	.932	.321
		2	.970	.551	.556	.488	.068*	.939	.294
	B	1	.967	.926	.243	.779	.517	.605	.450
		2	.933	.908	.328	.893	.645	.450	.537
	P	1	.462	.472	.038**	.961	.735	.775	.605
		2	.439	.560	.051*	.984	.780	.943	.596
B	I	1	.757	.844	.0003***	.404	.639	.896	.111
		2	.967	.740	.006***	.362	.443	.837	.063*
	B	1	.677	.214	.004***	.508	.047**	.510	.052*
		2	.398	.176	.014**	.310	.104	.256	.033**
	P	1	.630	.668	.202	.485	.824	.717	.613
C	I	1	.805	.637	.065*	.171	.803	.582	.387
	B	1	.777	.647	.199	.323	.255	.696	.272
	P	1	.414	.279	.159	.549	.409	.251	.435
D	I	1	.197	.722	.005***	.432	.790	.697	.551
	B	1	.967	.400	.042**	.805	.081*	.961	.410

*The exact specifications of the models are given in eq. (3). The symbols P, I, and B denote equations that apply to the peak, intermediate, and base periods, respectively.

Test type 2 tests the validity of the restriction that all the second-order price coefficients of (3) are simultaneously zero; test type 1 tests the restriction that both the first- and second-order price coefficients are simultaneously zero. A high probability (numbers close to 1.000) indicates inability to reject the restrictions. Significance at the 10, 5, and 1 percent levels is denoted by the symbols *, **, and ***, respectively.

Table 4-3. Tests for the Nonsignificance of Marginal Electricity Price Effects: Group II and III Tests* (Probabilities of Larger F Values)

Model	Regression	Test Type*	May	June	July	Aug.	Sept.	Oct.	Jul-Sep
						Group II			
	P	1	.828	.936	.981	.691	.911	.424	.980
C	I	1	.121	.689	.995	.850	.829	.356	.919
	B	1	.948	.574	.815	.660	.330	.210	.965
	P	1	.001***	.346	.806	.732	.383	.796	.632
D	I	1	.321	.922	.624	.645	.844	.708	.915
	B	1	.083*	.640	.224	.319	.680	.252	.783
						Group III			
	P	1	.516	.598	.891	.979	.866	.716	.914
C	I	1	.767	.704	.931	.965	.973	.899	.919
	B	1	.452	.949	.921	.976	.977	.652	.995
	P	1	.143	.108	.484	.627	.914	.683	.872
D	I	1	.158	.105	.516	.331	.806	.786	.847
	B	1	.699	.091*	.379	.179	.823	.154	.394

*The exact specifications of the models are given in eq. (3). The symbols P, I, and B denote equations that apply to the peak, intermediate, and base periods, respectively.

Test type 2 tests the validity of the restriction that all the second-order price coefficients of (3) are simultaneously zero; test type 1 tests the restriction that both the first- and second-order price coefficients are simultaneously zero. A high probability (numbers close to 1.000) indicates inability to reject the restrictions. Significance at the 10, 5, and 1 percent levels is denoted by the symbols *, **, and ***, respectively.

Those denoted as test type 1 report those probabilities associated with the restriction that both the first- and second-order price coefficients are simultaneously zero, i.e., that $U^k = V^k = 0$.

It is quite apparent from tables 4-2 and 4-3 that the hypothesis of nonsignificant overall price effects cannot be rejected in virtually all regressions. The obvious conclusion is that the response surface is generally "flat", i.e., unresponsive to marginal KWH price variation in the daily rating periods. However, these results do not imply the absence of TOU rate effects as was clearly shown in the analysis of chapter 3.

The results of the analyses of this chapter and chapter 3 can be combined to suggest the following policy implication: a shift from declining block to TOU rates will lead to reductions in peak and intermediate consumption, but variations of the marginal prices within a rating period will have little effect on KWH consumption in that period. It must be kept in mind that these implications are strictly valid only in predicting customer's responses to a TOU pricing scheme like that used in this demonstration. The conclusions do not necessarily apply to a differently conceived TOU rating plan, say, one in which a participation incentive was not built into the rates.

It should be noted that the nonsignificance of the price variables could be accounted for in part by the extremely small sample sizes which vary (see table 2-3), depending on the particular month, from 55 to 63 for Group I, from 18 to 23 for Group II, and from 25 to 27 for Group III.

Since the price effects in all the demand models of eq. (3) are generally nonsignificant, only model A price and income elasticities are presented for Group I in table 4-4 and only model C elasticities are presented for Groups II and III in tables 4-5 and 4-6, respectively. The row and column

Table 4-4. Price and Income Elasticities: Model A, Group I.[1]

May (df=43)

	P	I	B	Y
P	.596	1.017	-.561	.083
	(1.00)	(1.08	(-1.25)	(0.64)
I	.467	.546	-.389	.095
	(0.85)	(0.63)	(-0.94)	(0.79)
B	.566	.706	-.381	.140
	(0.98)	(0.78)	(-0.88)	(1.12)

June (df=46)

	P	I	B	Y
P	-.094	-.425	-.037	.225
	(-0.15)	(-0.41)	(-0.91)	(1.67)
I	.316	-.225	-.184	.199
	(0.56)	(0.25)	(-0.42)	(1.68)
B	-.037	.027	-.207	.220**
	(-0.07)	(0.03)	(-0.52)	(2.05)

July (df=41)

	P	I	B	Y
P	.761	-1.082	.144	.250*
	(1.14)	(-1.12)	(0.30)	(1.90)
I	1.015*	-.573	-.153	.235
	(1.79)	(-0.73)	(-.37)	(2.11)
B	.641	-.470	-.180	.251**
	(1.09)	(-0.58)	(-0.42)	(2.18)

August (df=42)

	P	I	B	Y
P	1.165	-1.130	.018	.179
	(1.67)	(-1.09)	(0.03)	(1.20)
I	1.088*	-.575	-.196	.175
	(1.99)	(-0.71)	(-0.48)	(1.50)
B	.528	-.542	-.174	.171
	(0.94)	(-0.65)	(-0.42)	(1.42)

September (df=44)

	P	I	B	Y
P	.435	-1.048	.316	.225**
	(0.85)	(-1.46)	(0.85)	(2.05)
I	.713	-.887	.127	.257**
	(1.42)	(-1.26)	(0.35)	(2.38)
B	1.000	-.018	-.110	.119
	(1.51)	(-0.02)	(-0.23)	(0.83)

October (df=39)

	P	I	B	Y
P	.269	-.926	.111	.285
	(0.30)	(-0.70)	(0.18)	(1.61)
I	.195	-.395	-.084	.297*
	(0.23)	(-0.32)	(-0.14)	(1.79)
B	.027	-.531	-.337	.267
	(0.03)	(-0.42)	(-0.56)	(1.61)

Aggregate, July-September (df=36)

	P	I	B	Y
P	.503	-.996	.205	.210*
	(0.84)	(-1.29)	(0.52)	(1.78)
I	.728	-.727	-.029	.235**
	(1.35)	(-1.04)	(-0.08)	(2.20)
B	.812	-.525	-.191	.196*
	(1.39)	(-0.68)	(-0.49)	(1.70)

[1]The exact specification of the model is given in equation (3). The total number of observations (n) for each regression is given in table 2-3. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

Tables C-1 through C-3 provide analogous results for models B, C, and D applied to Group I.

Table 4-5. Price and Income Elasticities: Model C, Group II.[1]

May (df=7)	P	I	B	Y
P	1.39	1.42	-1.12	.057
	(0.81)	(0.81)	(-0.74)	(0.26)
I	.494	.267	-.095	-.020
	(0.25)	(0.13)	(-0.05)	(-0.08)
B	1.186	1.485	-1.071	-.169
	(0.46)	(0.56)	(-0.46)	(-0.51)

June (df=7)	P	I	B	Y
P	.794	1.301	-.931	-.043
	(0.51)	(0.63)	(-0.62)	(-0.13)
I	1.372	2.684	-1.800	.010
	(0.83)	(1.23)	(-1.13)	(-0.02)
B	2.178	3.553	-2.715	-.050
	(1.11)	(1.36)	(-1.43)	(-0.12)

July (df=8)	P	I	B	Y
P	-.640	-1.181	.867	-.542
	(-0.21)	(-0.33)	(0.35)	(-0.98)
I	-.413	-.462	.491	-.475
	(-0.13)	(-0.13)	(0.19)	(-0.85)
B	1.581	2.217	-1.808	-.276
	(0.64)	(0.76)	(-0.88)	(-0.62)

August (df=8)	P	I	B	Y
P	.845	-1.450	-.103	-.399
	(0.20)	(-0.24)	(-0.02)	(-0.77)
I	.591	-1.416	-.339	-.471
	(0.13)	(-0.23)	(-0.07)	(-0.87)
B	3.181	4.028	-3.381	.157
	(1.14)	(1.02)	(-1.17)	(0.46)

September (df=6)	P	I	B	Y
P	-.592	.679	-.177	-.059
	(-0.25)	(0.18)	(-0.07)	(-0.13)
I	.056	1.851	-1.011	.045
	(0.03)	(0.55)	(-0.44)	(0.12)
B	2.696	5.350	-3.791*	.043
	(1.61)	(1.93)	(-2.00)	(0.13)

October (df=10)	P	I	B	Y
P	2.393	2.395	-2.294	-.266
	(1.45)	(0.99)	(-1.45)	(-0.82)
I	2.420	2.684	-2.256	-.162
	(1.79)	(1.35)	(-1.73)	(-0.61
B	4.523*	5.782	-4.718*	.001
	(2.02)	(1.76)	(-2.19)	(0.00)

Aggregate, July-September (df=5)	P	I	B	Y
P	-.782	-.593	.599	-.244
	(-0.41)	(-0.23)	(0.32)	(-0.58)
I	-.830	-.334	.695	-.284
	(-0.54)	(-0.16)	(0.47)	(-0.85)
B	.797	1.180	-.845	-.146
	(0.44)	(0.48)	(-0.48)	(-0.37)

[1]The exact specification of the model is given in equation (3). The total number of observations (n) for each regression is given in table 2-3. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

Table 4-6. Price and Income Elasticities: Model C, Group III.[1]

May (df=12)				
	P	I	B	Y
P	.743	1.079	-.504	-.240
	(1.472)	(0.75)	(-0.86)	(-1.10)
I	.242	1.552	-.563	-.195
	(0.47)	(1.05)	(-0.93)	(-0.88)
B	.738	.522	-.622	.037
	(1.57)	(0.93)	(-1.13)	(0.18)

June (df=14)				
	P	I	B	Y
P	.625	.295	-.422	.172
	(1.31)	(0.22)	(-0.78)	(0.83)
I	.495	1.456	-.625	.096
	(0.97)	(1.00)	(-1.08)	(0.43)
B	.247	.751	-.358	.268
	(0.45)	(0.48)	(-0.57)	(1.11)

July (df=14)				
	P	I	B	Y
P	.217	-.878	.060	.343
	(0.35)	(-0.54)	(0.10)	(1.39)
I	.435	.168	-.180	.203
	(0.66)	(0.10)	(-0.27)	(0.77)
B	.177	-.167	.142	.351*
	(0.35)	(-0.13)	(0.28)	(1.77)

August (df=14)				
	P	I	B	Y
P	.202	-.086	-.137	.267
	(0.31)	(-0.05)	(-0.21)	(1.07)
I	.295	.586	-.294	.211
	(0.46)	(0.38)	(-0.46)	(0.87)
B	.210	.403	-.280	.174
	(0.32)	(0.25)	(-0.43)	(0.71)

September (df=14)				
	P	I	B	Y
P	.040	-.625	-.041	.395*
	(0.08)	(-0.45)	(-0.07)	(1.92)
I	.220	.206	-.211	.224
	(0.41)	(0.13)	(-0.34)	(0.98)
B	-.207	-.491	.285	.240
	(-0.35)	(-0.29)	(0.96)	(0.96)

October (df=12)				
	P	I	B	Y
P	.295	-.615	-.207	.241
	(0.63)	(-0.42)	(-0.39)	(0.41)
I	.289	-.347	-.148	.235
	(0.55)	(-0.22)	(-0.25)	(0.93)
B	.080	-.945	-.126	.274
	(0.17)	(-0.65)	(-0.24)	(1.23)

Aggregate, July-September (df=14)				
	P	I	B	Y
P	.128	-.309	-.146	.316
	(0.24)	(-0.21)	(-0.26)	(1.36)
I	.363	.493	-.332	.167
	(0.66)	(0.33)	(-0.56)	(0.70)
B	-.096	.169	-.028	.313
	(-0.17)	(0.11)	(-0.05)	(1.30)

[1]The exact specification of the model is given in equation (3). The total number of observations (n) for each regression is given in table 2-3. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

headings indicate which elasticities are involved. Thus, an estimate in a row headed by P and column headed by I is a cross-elasticity of demand for electricity during the peak period with respect to a change in the marginal price during the intermediate period. Similarly B and Y denote the base period and income, respectively. For example, in the aggregate regression of table 4-4 the estimate -.191 in the row headed by a B and the column headed by a B is the estimated own-price elasticity of demand for electricity during the base period; similarly, the estimate .812 in the row headed by a B and the column headed by a P is the estimated cross-elasticity of demand for electricity during the base period with respect to the peak period price. These tables also report the number of degrees of freedom involved for each regression; t-statistics are reported in parentheses below the estimated coefficients.

The presence of positive own-price elasticity estimates in the tables is contrary to economic theory. In nearly all cases, however, the estimates are not significantly different from zero, as evidenced by the small associated t-ratios. Therefore, these unexpected estimates cannot be interpreted as a refutation of the theory.

Appendix tables C-1 through C-3 correspond to table 4-4 for models B, C, and D, respectively; and tables C-4 and C-5 correspond to tables 4-5 and 4-6 for model D. Basically the results presented there are not substantively different from those reported in tables 4-4 through 4-6. Appendix C also contains a detailed reporting of all the regressions based on the aggregate (July-September) data for all models estimated in each of the three groups. Those regressions were chosen for presentation because they are quite representative of individual monthly regressions. The interested reader is also referred to those regressions as a source of the estimated effects of the demographic variables on electricity consumption during each rating period.

In summary the demand analysis led to the conclusion that differences in the <u>marginal</u> KWH prices (i.e., the peak, intermediate, and base prices) within the daily rating periods defined in the Arizona study caused no significant differences in KWH consumption during those periods among households that participated in the experiment. However, this finding should not obscure the finding reported in chapter 3 that <u>any one</u> of the TOU rates is likely to cause shifts in electricity consumption among those daily rating periods compared to the consumption patterns observed under conventional declining block rates. Intuitively, the results of this chapter suggest that, once the daily rating periods are established, the time-of-use electricity consumption shifts that would accompany changes in marginal KWH prices would be small or non-existent. However, this inference is tempered by the complexities of the marginal price definitions in the Arizona study and by the fact of small sample sizes which impaired our efforts to discern price effects.

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APPENDIX A: DETAILED LISTING OF EXCLUSIONS FROM THE SAMPLE

Table A-1 lists all Group I, II, and III customers in the Arizona study and indicates whether they were deleted from the regression analyses, and, if so, those months during which they were deleted. The reader can refer back to table 1-2 for a detailed description of the rate each customer faced.

Under the heading 'deleted' are seven columns entitled May,...,Jul-Sep. These represent the seven time periods for which the analyses were performed. A dot (.) in one of the seven columns indicates that the corresponding customer was deleted from the elasticity estimation analysis for that time period. The reasons for deletions are indicated in one or more of the preceding columns. If the reason for a deletion was "no demo file" or "income not reported" then the customer was not deleted in the analysis of load shifting behavior of chapter 3.

Table A-1. Arizona Sample Edits

Customer Identifier*	Rate	Zero to near zero usage**	No demo. file	Zero discount**	Income not reported	Change in home owner***	Other	Deleted (.)						
								May	Jun	Jul	Aug	Sep	Oct	Jul-Sep
Group I:														
1.	16													
2.	5													
3.	8													
4.	11													
5.	5													
6.	7			5				•						
7.	15													
8.	13			7						•				•
9.	4													
10.	1													
11.	8													
12.	10													
13.	3			7						•				•
14.	12													
15.	6													
16.	14			5				•						
17.	1			5				•						
18.	16	5				5/76		•	•	•	•	•	•	•
19.	9													
20.	9			7,8,9,10						•	•	•	•	•
21.	3				X			•	•	•	•	•	•	•
22.	4													
23.	6			5										
24.	1			10									•	
25.	2			7,10						•			•	•
26.	5			6					•					
27.	12			6,7					•	•				
28.	9													
29.	6	7,8,9		9						•	•	•		•
30.	5			6,10					•				•	
31.	15			7						•				•
32.	10													
33.	7													

Table A-1. (Continued)

Customer Identifier*	Rate	Zero to near zero usage**	No demo. file	Zero discount**	Income not reported	Change in home owner***	Other	Deleted (.) May	Jun	Jul	Aug	Sep	Oct	Jul-Sep
Group I:														
34.	2													
35.	11													
36.	11					7/75		.	.	.	.	.	.	.
37.	13						5,7,8, 9,10	.		.	.	.	.	.
38.	13													
39.	10													
40.	10										.			.
41.	16	8,9,10									.	.	.	.
42.	6													
43.	1													
44.	12													
45.	16													
46.	4													
47.	14													
48.	8			5,6,7,8, 9,10				.	.	.	.	.	.	.
49.	2	10	X		X			.	.	.	.	.	.	.
50.	10													
51.	4													
52.	2				X			.	.	.	.	.	.	.
53.	2			6					.					
54.	3			10									.	
55.	7			5				.						
56.	12			10		8/76		.	.	.	.	.	.	.
57.	14													
58.	12													
59.	14		X		X		8,9,10	.	.	.	.	.	.	.
60.	8													
61.	15													
62.	14													
63.	13													
64.	9				X			.	.	.	.	.	.	.
65.	6													

Table A-1. (Continued)

Customer Identifier*	Rate	Zero to near zero usage**	No demo. file	Zero discount**	Income not reported	Change in home owner***	Other	Deleted (.) May	Jun	Jul	Aug	Sep	Oct	Jul-Sep
Group I:														
66.	7			8,10							.		.	.
67.	11	7,8								.	.			.
68.	13													
69.	3			5,6,7,8, 9,10				.	.	.	.	.	.	.
70.	4									.	.	.	.	.
71.	15	9,10												
72.	7													
73.	15			5				.						
74.	1			10									.	
75.	16													
76.	11					8/76		.	.	.	.	.	.	.
77.	9													
78.	3			8,9,10							.	.	.	.
79.	5													
80.	8													
Group II:														
81.	21				X			.	.	.	.	.	.	.
82.	18							.						
83.	20													
84.	17			5				.						
85.	17			10		10/75		.	.	.	.	.	.	.
86.	21													
87.	22													
88.	20													
89.	22													
90.	18			6,7,8,9					.	.	.	.		.
91.				7						.				.
92.	19													
93.	19													

Table A-1. (Continued)

Customer Identifier*	Rate	Zero to near zero usage**	No demo. file	Zero discount**	Income not reported	Change in home owner***	Other	Deleted (.)						
								May	Jun	Jul	Aug	Sep	Oct	Jul-Sep
Group II:														
94.	22					9/76		.	.	.	.	.	.	.
95.	22													
96.	22				X			.	.	.	.	.	.	.
97.	21													
98.	19					7/76		.	.	.	.	.	.	.
99.	17													
100.	20			9								.		.
101.	17	9		5,6				.	.			.		.
102.	21			6			8,9		.	.	.	.		.
103.	18			5,10		7/76		.	.	.	.	.	.	.
104.	18			5,6				.	.					
105.	21													
106.	20			8,9,10							.	.	.	.
107.	19													
108.	19													
109.	17													
110.	18													
Group III:														
111.	23													
112.	25			10									.	
113.	27													
114.	28													
115.	26													
116.	28													
117.	24													
118.	28													
119.	26													
120.	25													
121.	26													
122.	24													
123.	26	5,6,7,8, 9,10	X		X			.	.	.	.	.	.	.

Table A-1. (Continued)

Customer Identifier*	Rate	Zero to near zero usage**	No demo. file	Zero discount**	Income not reported	Change in home owner***	Other	Deleted (.) May	Jun	Jul	Aug	Sep	Oct	Jul-Sep
Group III:														
124.	25				X			.	.	.	.	.	.	.
125.	23					9/76		.	.	.	.	.	.	.
126.	28													
127.	23													
128.	25			5				.						
129.	23													
130.	27													
131.	27													
132.	27													
133.	28													
134.	27													
135.	23													
136.	24													
137.	25													
138.	24			5,10				.					.	
139.	26													
140.	24													
		Totals:	Group I.					18	15	20	19	17	22	
			Group II.					10	10	9	9	11	7	
			Group III.					5	3	3	3	3	5	
								33	28	32	31	31	34	

*The identifiers used on the original project data file are in the possession of DOE.

**Entries denote the months during which the problem occurred.

***Entries denote the date that the problem occurred.

a/ Customer switched from air conditioning in 1975 to an evaporative cooler in 1976.

b/ Customer moved to a rest home.

c/ Customer on vacation.

APPENDIX B: DATA PROCESSING AND ANALYSIS PROCEDURES*

The aim of the programming system developed for the Arizona analysis was to create a unified set of compatible computer programs, which could be used repeatedly for each month of data to be analyzed. All programs were written in the software of the Statistical Analysis System (SAS) to enable efficient merging, editing, and interactions with needed statistical routines. Specifically, the following procedures of SAS 76.5 were used in the analysis: CONTENTS, CORR, FREQ, MATRIX, MEANS, PRINT, SCATTER, SORT, and SYSREG. Figure B-1 is the flow chart of the data processing and analysis procedures used in the Arizona analysis.

The data for our analysis were avilable from two sources:

1) The Department of Energy-maintained data base, consisting of usage, demographic, and load information supplied to DOE by the Arizona Public Service Company (APS).

2) The original complete demographic file as compiled by APS based on answers to their survey questionnaire and stored on magnetic tape by DOE.

On the DOE file, usage information was available for each hour of each day in the study.† It was necessary to aggregate the usage information by month and by period (i.e., base, intermediate, and peak). The aggregated data set was then converted into a SAS data set for further analysis.

Demographic information on test and control customers was obtained on three occasions. There were two interviews prior to the experimental period and one subsequent to it.§ The post-test interview was somewhat more

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*See also remarks on editing in chapter 2, section 4 of this report.

†DOE received monthly aggregates of hourly usage information and merely extrapolated daily values.

§Copies of the pre- and post-test interviews are given in Section V of Appendix B to the Arizona project final report (Arizona Solar Energy Research Commission, 1977).

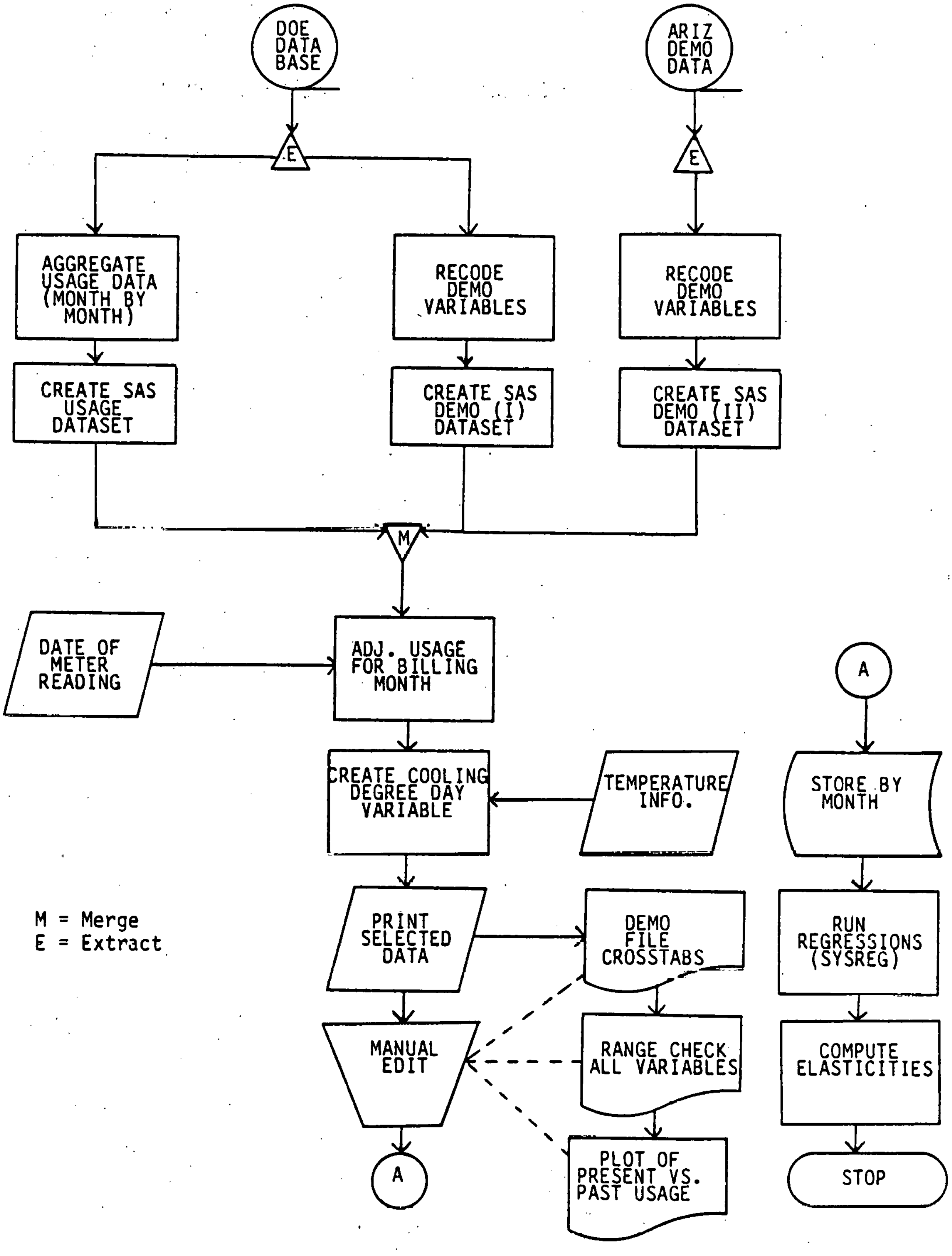

Figure B-1. Flow chart of data processing and analysis procedures used in the Arizona analysis.

detailed than the pre-test interviews. Coded responses to all three interviews were delivered to DOE. From the information contained in these three questionnaires, DOE developed a demographic data file containing coded responses for each of the three interviews. However, this file included responses to only a selected subset of the questions.

Because the information contained in this subset of all of the demographic data was considered insufficient for a satisfactory covariate analysis, RTI requested from DOE, and was sent, the complete set of coded responses to the post-test questionnaire (supplied to DOE by the Arizona project team). It was this complete set of responses that was eventually used to create a demographic data set for use in the analyses of this report.

The demographic variables were then recoded into a form more suitable for analysis (e.g., numerical instead of alphabetic values, taking logarithms, etc.), and then were also converted to a SAS data set. All three files were then sorted and linked and checked for non-matching customer ID's. Finally, a combined SAS data set was created for each month of the study.

Since the DOE data were based on calendar months, whereas the usage information supplied by APS was actually for billing months, the aggregated usage values were dependent on the length of the interval on which a customer's meter was read (see section 2.4). Thus each customer's aggregation value was not directly compatible to another customer's value. To adjust each monthly aggregation, each customer's usage was divided by the length of his billing month.

The number of cooling degree days in the billing months of each customer were then estimated from the calendar month cooling degree day totals and the meter read dates.

Once the complete data set was created, manual edits were then performed to check for missing values and reasonableness of the data. The manual edit checks were as follows:

1) Observations with extremely high and low values for demographic and usage variables were printed and examined to check for reasonableness.

2) Frequencies and cross-tabulations were printed for relevant variables in the demographic file using SAS procedure FREQ. Eyeball checks for unreasonable values and unreasonable crosstabs were made. Missing data problems were also examined.

3) Plots of present vs. past average daily usage were made for each month (e.g., usage 9/77 vs. usage 9/76).

All data that seemed unreasonable were then further examined as necessary to consider whether the observation merited deletion from the sample.

At the completion of editing, data analyses were completed using the SAS76.5 SYSREG and means procedures. Elasticities and their associated covariances were also computed with a user-written program that utilized the MATRIX procedure of SAS76.5.

APPENDIX C: DETAILED REGRESSION RESULTS FOR DEMAND MODELS

This appendix contains both the tables that correspond to tables 4-4 through 4-6 for the other response surface models that were estimated and duplications of the complete regression models that correspond to the aggregate (July-September) regressions for each model. These are included as representative regressions since they generally differ little from the results for individual months.

The tables listing the price and income elasticities for the various models and their locations in this report are:

Model	Group	Table
A	I	4-4
B	I	C-1
C	I	C-2
C	II	4-5
C	III	4-6
D	I	C-3
D	II	C-4
D	III	C-5

All of the variables in the reported regressions are defined in table 4-1, reprinted below.

The detailed regressions contain not only the estimated coefficients and the usual overall regression statistics but also the Chow tests that are reported for all regressions (including those for individual months) in tables 4-2 and 4-3. For all Group I regressions both test types 1 and 2 (as defined in table 4-2) are given in that order just following the regressions. For the Group II and Group III regressions, test 1 is given (as defined in table 4-3). In the following listing the detailed regressions for the aggregated data set (July-September) are labeled using three-symbol codes. The first symbol indicates the group to which the regression applies; the second indicates the model code from equation (3);

Table 4-1. Definitions of Variables

Variable	Definition
Non-price Independent Variables*	
z_1 (NOHOME)	1, if there were more household members than working members, 0, otherwise.
z_2 (YUMA)	1, if the household was located in Yuma, 0, otherwise.
z_3 (LNOHHMEM)	natural logarithm of the number of household members.
z_4 (LWATT)	natural logarithm of the sum of the wattage ratings of household appliances other than air conditioners.
z_5 (AC)	air conditioned square footage, estimated as the square square footage of the home, if it had central air conditioning; and as one plus the reported number of room air conditioners (to account for the fact that at least one room air conditioner in a home is often larger) times the average square footage per room in the house, if it had at least one room air conditioner; otherwise, zero.
z_6 (LINCOME)	natural logarithm of reported gross family income.
z_7 (KIDS)	1, if at least one resident in the household was less than six years old, 0, otherwise.
z_8 (LKWH6)	natural logarithm of the proportion of days in each household's billing month accounted for by weekends and holidays.
z_9 (LCDD6)	cooling requirements, measured as the product of the logarithm of average daily cooling degree days in each customer's billing month and the logarithm of air conditioned square footage, i.e., of z_5.
z_{10} (LAGEHM)	natural logarithm of the age of each customer's home.

*The Statistical Analysis System (SAS) acronyms are given in parentheses.

Table 4-1. (Continued)

Variable	Definition
Price Variables	
LPPA	$\ln p_1$, natural logarithm of peak price.
LPMA	$\ln p_2$, natural logarithm of intermediate price.
LPBA	$\ln p_3$, natural logarithm of base price.
LPP2	$\ln p_1$ squared.
LPM2	$\ln p_2$ squared.
LPB2	$\ln p_3$ squared.
LPPPM	$\ln p_1$ times $\ln p_2$.
LPPPB	$\ln p_1$ times $\ln p_3$.
LPMPB	$\ln p_2$ times $\ln p_3$.
Consumption Variables	
LKWHPEAK, LKWHINTR, LKWHBASE	natural logarithm of the average daily KWH consumption for the 1976 (test year) billing month during the peak, intermediate, and base rating periods, respectively.
LKWHPK5, LKWHIN5, LKWHBS5	natural logarithm of the estimated average daily KWH consumption for the 1975 (baseline year) billing month during the hours of the day assigned to the peak, intermediate, and base rating periods in the following (test) year.

and the third indicates the rating period to which the results apply (P, I, B refer to peak, intermediate, and base periods). For example regression I-A-P is the model A regression for Group I customers for the peak period.

The tables in which the regressions can be located are:

Group I Regressions	Table
I-A-P	C- 6
I-A-I	C- 7
I-A-B	C- 8
I-B-P	C- 9
I-B-I	C-10
I-B-B	C-11
I-C-P	C-12
I-C-I	C-13
I-C-B	C-14
I-D-P	C-15
I-D-I	C-16
I-D-B	C-17
I-X-P	C-18
I-X-I	C-19
I-X-B	C-20

Group II Regressions	Table
II-C-P	C-21
II-C-I	C-22
II-C-B	C-23
II-D-P	C-24
II-D-I	C-25
II-D-B	C-26
II-X-P	C-27
II-X-I	C-28
II-X-B	C-29

Group III Regressions	Table
III-C-P	C-30
III-C-I	C-31
III-C-B	C-32
III-D-P	C-33
III-D-I	C-34
III-D-B	C-35
III-X-P	C-36
III-X-I	C-37
III-X-B	C-38

Table C-1. Price and income elasticities: Model B, Group I.[1]

May (df=51)				
	P	I	B	Y
P	.162	.280	-.099	.143
	(0.62)	(0.64)	(-0.47)	(1.36)
I	.000	-.047	-.036	.202**
	(0.00)	(-0.14)	(-0.23)	(2.02)
B	.099	.219	.115	.264**
	(0.47)	(0.62)	(0.67)	(2.47)

June (df=54)				
	P	I	B	Y
P	-.599**	-.556	.179	.129
	(-2.07)	(-1.05)	(0.72)	(1.13)
I	-.216	-.503	.167	.176
	(-0.91	(-1.15)	(-0.82)	(1.65)
B	-.477*	-.810*	.267	.213*
	(-1.83)	(-1.70)	(1.20)	(1.98)

July (df=49)				
	P	I	B	Y
P	-.122	-1.056**	.352	.263**
	(-0.36)	(-2.05)	(1.33)	(2.30)
I	.168	-.597*	.183	.277***
	(0.73)	(-1.70)	(1.01)	(2.68)
B	.051	-.538	.256	.155
	(0.18)	(-1.24)	(1.15)	(1.49)

August (df=50)				
	P	I	B	Y
P	.280	-.278	-.006	.154
	(0.86)	(-0.48)	(-0.02)	(1.25)
I	.146	.098	-.114	.180
	(0.66)	(0.25)	(-0.59)	(1.65)
B	-.218	-.174	.109	.186*
	(-0.82)	(-0.37)	(0.47)	(1.94)

September (df=52)				
	P	I	B	Y
P	-.103	-.586*	.137	.171
	(-0.47)	(-1.73)	(0.79)	(1.62)
I	.013	-.597*	.196	.157
	(0.07)	(-2.05)	(1.32)	(1.64)
B	.121	-.479	.313	.215*
	(0.33)	(-0.85)	(1.09)	(1.94)

October (df=47)				
	P	I	B	Y
P	.048	.231	-.211	.287**
	(0.12)	(0.36)	(-0.66)	(2.32)
I	-.118	.754	-.193	.298**
	(-0.32)	(1.27)	(-0.66)	(2.59)
B	-.459	.350	-.269	.316**
	(-0.38)	(0.38)	(-0.59)	(2.43)

Aggregate, July-September (df=36)				
	P	I	B	Y
P	.052	0.229	-1.34***	.169
	(0.17)	(1.03)	(-3.09)	(1.50)
I	.125	-1.137**	.144	.174*
	(0.42)	(-2.78)	(0.69)	(1.75)
B	-.057	-1.253**	.367	.162
	(-0.18)	(-2.93)	(1.68)	(1.64)

[1]The exact specification of the model is given in equation (3). The total number of observations (n) for each regression is given in table 1-2. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

Note: Elasticities for model A, Group I are given in table 4-4.

Table C-2. Price and income elasticities: Model C, Group I.[1]

May (df=49)

	P	I	B	Y
P	.132	.062	-.246	.118
	(0.26)	(0.16)	(-1.07)	(0.98)
I	.219	.107	-.194	.103
	(0.49)	(0.32)	(-0.94)	(0.95
B	.265	.359	-.164	.167
	(0.56)	(1.01)	(-0.76)	(1.46)

June (df=52)

	P	I	B	Y
P	-.116	-.275	-.075	.199
	(-0.21)	(-0.73)	(-0.31)	(1.54)
I	.279	-.163	-.166	.179
	(0.58)	(-0.49)	(-0.77)	(1.58)
B	-.032	.076	-.181	.207**
	(-0.07)	(0.26)	(-0.96)	(2.08)

July (df=47)

	P	I	B	Y
P	.613	-.498	.158	.226*
	(1.06)	(-1.20)	(0.61)	(1.81)
I	.860*	-.473	-.021	.221**
	(1.74)	(-1.33)	(-0.09)	(2.08)
B	.685	-.425	-.047	.232**
	(1.31)	(-1.13)	(-0.20)	(2.07)

August (df=48)

	P	I	B	Y
P	.950	.123	-.178	.081
	(1.54)	(0.27)	(-0.64)	(0.57)
I	1.079**	.254	-.305	.103
	(2.27)	(0.74)	(-1.42)	(0.94)
B	.729	.355	-.374*	.123
	(1.56)	(1.05)	(-1.77)	(1.13)

September (df=50)

	P	I	B	Y
P	0.64	-.249	.116	.150
	(0.14)	(-0.76)	(0.56)	(1.38)
I	.293	-.139	-.057	.185*
	(0.66)	(-0.43)	(-0.28)	(1.71)
B	1.029*	.167	-.116	.129
	(1.90)	(0.42)	(-0.46)	(0.98)

October (df=45)

	P	I	B	Y
P	.126	.006	-.280	.278*
	(0.19)	(0.01)	(-0.96)	(1.72)
I	.117	.178	-.346	.294*
	(0.19)	(0.43)	(-1.27)	(1.96)
B	.443	.318	-.341	.285*
	(0.67)	(0.74)	(-1.19)	(1.81)

Aggregate, July-September (df=42)

	P	I	B	Y
P	.244	-.348	.106	.141
	(0.47)	(-0.98)	(0.47)	(1.24)
I	.529	-.281	-.081	.179*
	(1.13)	(-0.87)	(-0.40)	(1.74)
B	.827*	-.140	-.186	.172
	(1.69)	(-0.41)	(-0.87)	(1.59)

[1]The exact specification of the model is given in equation (3). The total number of observations (n) for each regression is given in table 1-2. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

Table C-3. Price and income elasticities: Model D, Group I.[1]

May (df=57)				
	P	I	B	Y
P	.062	-.238	.008	.143
	(0.29)	(-1.42)	(0.07)	(1.36)
I	-.044	-.267**	.040	.202**
	(-0.26)	(-2.01)	(0.49)	(2.02)
B	.067	-.033	-.002	.264**
	(0.35)	(-0.22)	(-0.03)	(2.47)

June (df=60)				
	P	I	B	Y
P	-.245	-.072	-.074	.129
	(-1.00)	(-0.38)	(-9.62)	(1.13)
I	.085	-.112	-.033	.176
	(0.43)	(-0.74)	(-0.34)	(1.65)
B	-.026	-.038	-.133	.213*
	(-0.10)	(-0.20)	(-1.12)	(1.98)

July (df=55)				
	P	I	B	Y
P	.421	-.226	.085	.263**
	(1.44)	(-0.98)	(0.58)	(2.30)
I	.642***	-.170	-.004	.277***
	(3.02)	(-1.02)	(-0.04)	(2.68)
B	.531**	-.262	.027	.155
	(2.05)	(-1.28)	(0.20)	(1.49)

August (df=56)				
	P	I	B	Y
P	.306	-.001	-.129	.154
	(1.19)	(-0.00)	(-1.01)	(1.25)
I	.271	.051	-.105	.180
	(1.56)	(0.37)	(-1.22)	(1.65)
B	.080	.046	-.101	.186*
	(0.36)	(0.25)	(-0.91)	(1.94)

September (df=58)				
	P	I	B	Y
P	.061	-.196	.027	.171
	(0.36)	(-1.45)	(0.31)	(1.62)
I	.017	-.107	.004	.157
	(0.11)	(-0.84)	(0.05)	(1.64)
B	.583*	.023	.058	.215*
	(1.95)	(0.10)	(0.39)	(1.96)

October (df=53)				
	P	I	B	Y
P	.057	-.103	-.178	.287**
	(0.20)	(-0.49)	(-1.32)	(2.32)
I	-.185	-.029	-.047	.298**
	(-0.69)	(-0.15)	(-0.38)	(2.59)
B	-.183	.068	.024	.316**
	(-0.38)	(0.20)	(0.11)	(2.43)

Aggregate, July-September (df=50)				
	P	I	B	Y
P	.137	-.138	-.001	.169
	(0.84)	(-1.12)	(-0.01)	(1.50)
I	.173	-.030	-.028	.174*
	(1.28)	(-0.30)	(-0.44)	(1.75)
B	.268	-.099	.010	.162
	(1.26)	(-0.62)	(0.10)	(1.64)

[1]The exact specification of the model is given in equation (3). The total number of observations (n) for each regression is given in table 1-2. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

Table C-4. Price and income elasticities: Model D, Group II.[1]

May (df=15)	P	I	B	Y
P	.764*	.649	-.933***	.213
	(2.04)	(1.68)	(-3.14)	(1.23)
I	-1.272*	-.607	.755	.175
	(-1.76)	(-0.84)	(1.32)	(1.14)
B	2.586**	1.298	-1.754*	.219
	(2.46)	(1.11)	(-1.99)	(0.83)

June (df=15)	P	I	B	Y
P	-.439	.321	.043	.120
	(-0.70)	(0.43)	(0.08)	(0.47)
I	.005	.306	-.013	.325
	(0.01)	(0.26)	(-0.01)	(1.14)
B	-.706	-.929	.605	.030
	(-1.01)	(-1.24)	(1.10)	(0.11)

July (df=16)	P	I	B	Y
P	-.052	-.428	.040	-.287
	(-0.06)	(-0.43)	(0.06)	(-1.02)
I	.918	.503	-.763	-.187
	(0.93)	(0.43)	(-0.90)	(-0.70)
B	.787	1.017	-1.021	-.044
	(1.07)	(1.17)	(-1.61)	(-0.16)

August (df=16)	P	I	B	Y
P	-.510	-.411	.196	-.383
	(-0.57)	(-0.38)	(0.25)	(-0.74)
I	-.487	-.304	.507	-.395
	(-0.61)	(-0.30)	(0.72)	(-0.76)
B	-1.409	-1.499	1.556	-.339
	(-1.18)	(-0.98)	(1.47)	(-0.77)

September (df=14)	P	I	B	Y
P	-1.087	-.072	.582	.042
	(-1.10)	(-0.06)	(0.67)	(0.17)
I	-.581	-.130	.413	.098
	(-0.53)	(-0.09)	(0.43)	(0.35)
B	.134	.704	-.149	.006
	(0.15)	(0.63)	(-0.19)	(0.02)

October (df=18)	P	I	B	Y
P	-.275	-.780	.291	.247
	(-0.30)	(-0.68)	(0.36)	(0.84)
I	.160	-.700	.268	.294
	(0.16)	(-0.56)	(0.31)	(0.94)
B	1.741*	1.791*	-1.396*	.096
	(2.10)	(1.75)	(-1.93)	(0.28)

Aggregate, July-September (df=13)	P	I	B	Y
P	-.740	-.328	.397	-.051
	(-1.03)	(-0.35)	(0.63)	(-0.21)
I	-.285	-.061	.232	-.008
	(-0.36)	(-0.06)	(0.33)	(-0.03)
B	.289	.420	-.174	-.118
	(0.51)	(0.57)	(-0.35)	(-0.49)

[1]The exact specification of the model is given in equation (3). The total number of observations (n) for each regression is given in table 1-2. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

Table C-5. Price and income elasticities: Model D, Group III.[1]

May (df=20)	P	I	B	Y
P	-.037	1.377**	-.410*	.060
	(-0.19)	(2.39)	(-2.07)	(0.30)
I	-.045	1.536**	-.309	.191
	(-0.20)	(2.35)	(-1.38)	(0.76)
B	.182	.370	-.141	.047
	(0.99)	(0.68)	(-0.75)	(0.32)

June (df=22)	P	I	B	Y
P	.525**	.260	-.259	.171
	(2.542)	(0.45)	(-1.28)	(0.79)
I	.494*	2.047	-.358	.157
	(2.13)	(1.63)	(-1.57)	(0.72)
B	.435**	.679	-.229	.366
	(2.37)	(1.35)	(-1.27)	(1.71)

July (df=22)	P	I	B	Y
P	-.150	-.184	-.008	.277
	(-1.14)	(-0.51)	(-0.07)	(1.30)
I	-.037	.792	-.169	.325
	(-0.19)	(1.50)	(-0.89)	(1.26)
B	-.049	-.118	.170	.365*
	(-0.42)	(-0.37)	(1.50)	(1.98)

August (df=22)	P	I	B	Y
P	.088	-.102	.064	.252
	(0.87)	(-0.36)	(0.64)	(1.17)
I	.101	.448	.003	.322
	(0.67)	(1.08)	(0.02)	(1.25)
B	.322**	.067	-.056	.285
	(2.26)	(0.16)	(-0.36)	(1.33)

September (df=22)	P	I	B	Y
P	-.063	-.349	.054	.251
	(-0.29)	(-0.58)	(0.26)	(1.22)
I	-.029	-.083	-.092	.361
	(-0.15)	(-0.16)	(-0.50)	(1.62)
B	.014	-.028	.147	.256
	(0.06)	(-0.04)	(0.62)	(1.25)

October (df=20)	P	I	B	Y
P	.131	-.356	.038	.120
	(0.88)	(-0.80)	(0.25)	(0.65)
I	.109	-.524	.275	.265
	(0.33)	(-0.51)	(0.81)	(1.34)
B	.470*	1.181	0.363	.216
	(1.78)	(1.54)	(-1.35)	(0.58)

Aggregate, July-September (df=22)	P	I	B	Y
P	-.032	-.219	.044	.285
	(-0.30)	(-0.76)	(0.43)	(1.46)
I	.022	.318	-.062	.354
	(0.17)	(0.86)	(-0.47)	(1.56)
B	.123	-.044	.101	.345*
	(0.97)	(-0.12)	(0.80)	(2.00)

[1]The exact specification of the model is given in equation (3). The total number of observations (n) for each regression is given in table 2-3. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

Table C-6. Model A, Regression for Group I, Peak Period (Average Day, July - September, 1976)

MODEL: D   DEP VARIABLE=LKWHPEAK

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	18	20.736601	1.152033	4.794	0.0001
ERROR	36	8.651670	0.240324		
CORRECTED TOT	54	29.388271	0.544227		RSQUARE = 0.7056

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
INTERCEPT	1	125.92202373 0.0470	61.23391013	2.05641
LPPA	1	-74.72243693 0.0519	37.16864535	-2.01036
LPMA	1	-55.66630993 0.0472	27.08789877	-2.05503
LPBA	1	23.03154220 0.1082	13.98278472	1.64714
LPP2	1	10.53572542 0.0669	5.57493263	1.88984
LPM2	1	2.13464634 0.2179	1.70219211	1.25406
LPB2	1	0.54130762 0.4902	0.77654924	0.69707
LPPPM	1	19.19574436 0.0646	10.07082870	1.90607
LPPPB	1	-9.35530236 0.1218	5.90425877	-1.58450
LPMPB	1	-0.20189174 0.8832	1.36481303	-0.14793
YUMA	1	0.39605112 0.1478	0.26778071	1.47901
KIDS	1	0.03006331 0.8934	0.22274504	0.13497
NOHOME	1	0.15387299 0.5730	0.27053160	0.56878
LWATT	1	0.17401621 0.0689	0.09281089	1.87495

SOURCE   DF   B VALUE   STD DEVIATION   T FOR H0:B=0

Table C-6. (continued)

```
                            PROB > |T|   LABEL

LNOHHMEM           1        0.25376418       0.22094970           1.14852
                                0.2583

LINCOME            1        0.21002721       0.11790972           1.78125
                                0.0833

LPWH6              1       -0.92106743       3.16371208          -0.29114
                                0.7726

LCDD6              1        0.05750426       0.01685908           3.41088
                                0.0016

LAGEHM             1       -0.19230855       0.11871998          -1.61985
                                0.1140

TEST:TEST001   NUMERATOR:        0.25037708   DF:   9   F VALUE:     1.0
418
               DENOMINATOR:      0.24032416   DF:  36   PROB > F:    0.4
273
TEST:TEST002   NUMERATOR:        0.29983571   DF:   6   F VALUE:     1.2
476
               DENOMINATOR:      0.24032416   DF:  36   PROB > F:    0.3
058
```

Table C-7. Model A, Regression for Group I, Intermediate Period (Average Day, July - September, 1976)

MODEL: E DEP VARIABLE=LKWHINTR

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	18	16.552066	0.919559	4.666	0.0001
ERROR	36	7.094360	0.197066		
CORRECTED TOT	54	23.646425	0.437897	RSQUARE = 0.7000	

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
INTERCEPT	1	112.26646404 0.0504	55.44962616	2.02466
LPPA	1	-66.05445069 0.0575	33.65761692	-1.96254
LPMA	1	-49.88249459 0.0494	24.52911887	-2.03360
LPBA	1	20.97236564 0.1063	12.00194146	1.65633
LPP2	1	9.25088268 0.0752	5.04831276	1.83247
LPM2	1	2.01365156 0.1997	1.54139946	1.30638
LPB2	1	0.43703024 0.5382	0.70319476	0.62149
LPPPM	1	17.32952110 0.0654	9.11951704	1.90027
LPPPB	1	-8.22915478 0.1325	5.34653007	-1.53916
LPMPB	1	-0.72200656 0.5627	1.23588992	-0.58420
YUMA	1	0.19996437 0.4150	0.24248558	0.82464
KIDS	1	0.05371272 0.7915	0.20170407	0.26629
NOHOME	1	0.04654296 0.8504	0.24497662	0.18999
LWATT	1	0.16260071 0.0609	0.08404378	1.93471

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0

Table C-7. (continued)

		PROB > |T|	LABEL	
LNOHHMEM	1	0.27824869 0.1729	0.20007832	1.39070
LINCOME	1	0.23503937 0.0342	0.10677172	2.20133
LPWH6	1	-0.68385586 0.8127	2.86486118	-0.23870
LCDD6	1	0.03663788 0.0217	0.01526654	2.39988
LAGEHM	1	-0.13719256 0.2101	0.10750544	-1.27615

TEST:TEST003	NUMERATOR:	0.23774588	DF:	9	F VALUE:	1.2	
064	DENOMINATOR:	0.19706554	DF:	36	PROB > F:	0.3	
213							
TEST:TEST004	NUMERATOR:	0.25077038	DF:	6	F VALUE:	1.2	
725	DENOMINATOR:	0.19706554	DF:	36	PROB > F:	0.2	
943							

Table C-8. Model A, Regression for Group I, Base Period
(Average Day, July - September, 1976)

MODEL: F DEP VARIABLE=LKWHBASE

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	18	16.094283	0.894127	3.871	0.0003
ERROR	36	8.315809	0.230995		
CORRECTED TOT	54	24.410092	0.452039		RSQUARE = 0.6593

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	LABEL	T FOR H0:B=0
INTERCEPT	1	101.61781180	0.0992	60.03358521		1.69268
LPPA	1	-61.23130406	0.1016	36.44005475		-1.68033
LPMA	1	-45.81361867	0.0931	26.55691390		-1.72511
LPBA	1	24.13082136	0.0869	13.70869011		1.76024
LPP2	1	9.04385103	0.1067	5.46565117		1.65467
LPM2	1	2.19371367	0.1970	1.66882524		1.31453
LPB2	1	0.69138901	0.3698	0.76132709		0.90814
LPPPM	1	15.68746192	0.1208	9.87341739		1.58886
LPPPB	1	-9.51218498	0.1090	5.78852177		-1.64328
LPMPB	1	-1.07198537	0.4283	1.33805957		-0.80115
YUMA	1	0.04688058	0.8593	0.26253159		0.17857
KIDS	1	0.05412146	0.8057	0.21837873		0.24783
NOHOME	1	-0.26565298	0.3232	0.26522856		-1.00160
LWATT	1	0.21308678	0.0248	0.09099159		2.34183

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0

Table C-8. (continued)

		PROB > |T|	LABEL	
LNOHHMEM	1	0.43871534 0.0503	0.21661858	2.02529
LINCOME	1	0.19633801 0.0981	0.11559842	1.69845
LPWH6	1	-0.23440626 0.9402	3.10169608	-0.07557
LCDD6	1	0.01861178 0.2676	0.01652860	1.12603
LAGEHM	1	-0.10591907 0.3689	0.11639279	-0.91001

TEST:TEST005 102	NUMERATOR:	0.23334479	DF:	9	F VALUE:	1.0
502	DENOMINATOR:	0.23099470	DF:	36	PROB > F:	0.4
TEST:TEST006 553	NUMERATOR:	0.19756915	DF:	6	F VALUE:	0.8
366	DENOMINATOR:	0.23099470	DF:	36	PROB > F:	0.5

Table C-9. Model B, Regression for Group I, Peak Period (Average Day, July - September, 1976)

MODEL: M   DEP VARIABLE=LKWHPEAK

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	10	27.835556	2.783556	78.879	0.0001
ERROR	44	1.552715	0.035289		
CORRECTED TOT	54	29.388271	0.544227	RSQUARE = 0.9472	

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	LABEL	T FOR H0:B=0
INTERCEPT	1	27.30130804	0.2338	22.61471358		1.20724
LPPA	1	-14.65765115	0.2900	13.68468376		-1.07110
LPMA	1	-14.53955139	0.1479	9.87077307		-1.47299
LPBA	1	7.75926703	0.1315	5.04848260		1.53695
LPP2	1	1.67266340	0.4245	2.07511012		0.80606
LPM2	1	-0.10499040	0.8679	0.62770951		-0.16726
LPB2	1	0.38022267	0.1760	0.27643510		1.37545
LPPPM	1	5.70313091	0.1246	3.64287927		1.56556
LPPPB	1	-3.32221359	0.1270	2.13600799		-1.55534
LPMPB	1	0.03567557	0.9427	0.49322278		0.07233
LKWHPK5	1	0.89941001	0.0001	0.03657162		24.59311

TEST		VALUE		DF		
TEST:TEST013	NUMERATOR:	0.02876575	DF:	9	F VALUE:	0.8151
	DENOMINATOR:	0.03528897	DF:	44	PROB > F:	0.6051
TEST:TEST014	NUMERATOR:	0.02724411	DF:	6	F VALUE:	0.7720
	DENOMINATOR:	0.03528897	DF:	44	PROB > F:	0.5961

Table C-10. Model B, Regression for Group I, Intermediate Period (Average Day, July - September, 1976)

MODEL: N   DEP VARIABLE=LKWHINTR

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	10	22.766637	2.276664	113.861	0.0001
ERROR	44	0.879789	0.019995		
CORRECTED TOT	54	23.646425	0.437897	RSQUARE = 0.9628	

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0
		PROB > |T|	LABEL	
INTERCEPT	1	22.40413667	17.04287847	1.31457
		0.1955		
LPPA	1	-11.78607627	10.31203142	-1.14294
		0.2592		
LPMA	1	-12.83746382	7.43055449	-1.72766
		0.0911		
LPBA	1	7.10859141	3.80327839	1.86907
		0.0683		
LPPPM	1	4.90936709	2.74332501	1.78957
		0.0804		
LPP2	1	1.22443669	1.56448116	0.78265
		0.4380		
LPM2	1	0.35017432	0.47053492	0.74420
		0.4607		
LPB2	1	0.28415674	0.20802470	1.36598
		0.1789		
LPPPB	1	-2.50534099	1.60949658	-1.55660
		0.1267		
LPMPB	1	-0.82476205	0.37077369	-2.22444
		0.0313		
LKWHINS	1	0.90786954	0.03120059	29.09783
		0.0001		

TEST:TEST015	NUMERATOR:	0.03452262	DF:	9	F VALUE:	1.7
265						
	DENOMINATOR:	0.01999520	DF:	44	PROB > F:	0.1
114						
TEST:TEST016	NUMERATOR:	0.04368742	DF:	6	F VALUE:	2.1
849						
	DENOMINATOR:	0.01999520	DF:	44	PROB > F:	0.0
625						

Table C-11. Model B, Regression Group I, Base Period (Average Day, July - September, 1976)

MODEL: B DEP VARIABLE=LKWHBASE

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	10	22.282056	2.228206	46.071	0.0001
ERROR	44	2.128036	0.048364		
CORRECTED TOT	54	24.410092	0.452039	RSQUARE = 0.9128	

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
INTERCEPT	1	7.69564825 0.7744	26.68641355	0.28837
LPPA	1	-4.13723497 0.7990	16.15212225	-0.25614
LPMA	1	-6.42160752 0.5837	11.63082764	-0.55212
LPBA	1	7.49041575 0.2150	5.99334112	1.25019
LPPPM	1	4.12286829 0.3399	4.27313320	0.96483
LPP2	1	-0.10548519 0.9660	2.45884383	-0.04290
LPM2	1	-0.99682111 0.1953	0.75802718	-1.31502
LPB2	1	0.55115464 0.0955	0.32347337	1.70386
LPPPB	1	-2.43511615 0.3389	2.51860441	-0.96685
LPMPB	1	-1.31169357 0.0278	0.57629732	-2.27607

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
LKWHBSS	1	0.98967516 0.0001	0.05262139	18.80747

TEST:TEST017	NUMERATOR:	0.10081519	DF:	9	F VALUE:	2.0845
	DENOMINATOR:	0.04836446	DF:	44	PROB > F:	0.0518
TEST:TEST018	NUMERATOR:	0.12315823	DF:	6	F VALUE:	2.5465
	DENOMINATOR:	0.04836446	DF:	44	PROB > F:	0.0333

Table C-12. Model C, Regression for Group I, Peak Period (Average Day, July - September, 1976)

MODEL: OL DEP VARIABLE=LKWHPEAK

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	18.937587	1.578132	6.342	0.0001
ERROR	42	10.450684	0.248826		
CORRECTED TOT	54	29.388271	0.544227	RSQUARE = 0.6444	

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	LABEL	T FOR H0:B=0
INTERCEPT	1	-1.71887011	0.6751	4.07197358		-0.42212
LPPA	1	0.24410542	0.6376	0.51448734		0.47446
LPMA	1	-0.34758493	0.3338	0.35549153		-0.97776
LPBA	1	0.10559942	0.6416	0.22524211		0.46883
YUMA	1	0.38538652	0.1338	0.25205610		1.52897
KIDS	1	-0.11344512	0.5777	0.20220073		-0.56105
NOHUME	1	0.05087331	0.8507	0.26869334		0.18934
LWATT	1	0.22827795	0.0126	0.08758151		2.60646
LNUHHMEM	1	0.39057174	0.0732	0.21250896		1.83791
LINCOME	1	0.14102996	0.2207	0.11343156		1.24330
LPWH6	1	-0.90169649	0.7685	3.04312237		-0.29631
LCDD6	1	0.06400071	0.0005	0.01687436		3.79278
LAGEHM	1	-0.23319638	0.0516	0.11641754		-2.00310

TEST:TEST007 NUMERATOR: 0.15145980 DF: 3 F VALUE: 0.6
087

DENOMINATOR: 0.24882581 DF: 42 PROB > F: 0.6
131

Table C-13. Model C, Regression for Group I, Intermediate Period (Average Day, July - September, 1976)

MODEL: EL DEP VARIABLE=LKWHINTR

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	15.047444	1.253954	6.125	0.0001
ERROR	42	8.598982	0.204738		
CORRECTED TOT	54	23.646425	0.437897	RSQUARE = 0.6364	

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
INTERCEPT	1	-0.97384360 0.7933	3.69365312	-0.26365
LPPA	1	0.52879563 0.2636	0.46668716	1.13308
LPMA	1	-0.28074234 0.3889	0.32246339	-0.87062
LPBA	1	-0.08080191 0.6945	0.20431523	-0.39548
YUMA	1	0.17425884 0.4502	0.22863798	0.76216
KIDS	1	-0.07633134 0.6794	0.18341459	-0.41617
NUHOME	1	-0.04699387 0.8480	0.24372947	-0.19281
LWATT	1	0.21324551 0.0104	0.07944445	2.68421
LNUHHMEM	1	0.39824428 0.0450	0.19276510	2.06596
LINCOME	1	0.17936732 0.0886	0.10289282	1.74324
LPWH6	1	-0.48937061 0.8601	2.76039081	-0.17728
LCDD6	1	0.04230550 0.0084	0.01530659	2.76387

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
LAGEHM	1	-0.17756702 0.1001	0.10560137	-1.68148

TEST:TEST008 NUMERATOR: 0.21169689 DF: 3 F VALUE: 1.0
340
DENOMINATOR: 0.20473766 DF: 42 PROB > F: 0.3
874

Table C-14. Model C, Regression for Group I, Base Period
(Average Day, July - September, 1976)

MODEL: FL   DEP VARIABLE=LKWHBASE

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	14.908868	1.242406	5.492	0.0001
ERROR	42	9.501224	0.226220		
CORRECTED TOT	54	24.410092	0.452039	RSQUARE = 0.6108	

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
INTERCEPT	1	-0.64451943 0.8690	3.88259750	-0.16600
LPPA	1	0.82700053 0.0992	0.49055998	1.68583
LPMA	1	-0.13981162 0.6821	0.33895862	-0.41247
LPBA	1	-0.18625661 0.3907	0.21476673	-0.86725
YUMA	1	-0.06700314 0.7818	0.24033368	-0.27879
KIDS	1	0.02853297 0.8831	0.19279694	0.14799
NOHOME	1	-0.27669627 0.2863	0.25619716	-1.08001
LWATT	1	0.23782215 0.0068	0.08350834	2.84789

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
LNOHHMEM	1	0.49014528 0.0200	0.20262577	2.41897
LINCOME	1	0.17242290 0.1184	0.10815618	1.59420
LPWH6	1	0.82591580 0.7773	2.90159528	0.28464
LCDD6	1	0.02014055 0.2176	0.01608958	1.25178
LAGEHM	1	-0.14721436 0.1919	0.11100328	-1.32622

TEST:TEST009 NUMERATOR: 0.30489607 DF: 3 F VALUE: 1.3
478
DENOMINATOR: 0.22621962 DF: 42 PROB > F: 0.2
718

Table C-15. Model D, Regression for Group I, Peak Period (Average Day, July -September, 1976)

MODEL: ML DEP VARIABLE=LKWHPEAK

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	27.672092	6.918023	201.553	0.0001
ERROR	50	1.716179	0.034324		
CORRECTED TOT	54	29.388271	0.544227	RSQUARE = 0.9416	

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
INTERCEPT	1	0.17019160 0.7086	0.45281294	0.37585
LPPA	1	0.13726583 0.4060	0.16381118	0.83795
LPMA	1	-0.13849535 0.2673	0.12345541	-1.12182
LPBA	1	-0.00103461 0.9894	0.07758929	-0.01333

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
LKWHPK5	1	0.88933984 0.0001	0.03287640	27.05101

TEST:TEST010	NUMERATOR:	0.03180903	DF:	3	F VALUE:	0.9267
	DENOMINATOR:	0.03432358	DF:	50	PROB > F:	0.4348

Table C-16. Model D, Regression for Group I, Intermediate Period (Average Day, July - September, 1976)

MODEL: NL DEP VARIABLE=LKWHINTR

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	22.504512	5.626128	246.347	0.0001
ERROR	50	1.141913	0.022838		
CORRECTED TOT	54	23.646425	0.437897	RSQUARE = 0.9517	

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0	PROB > |T|	LABEL
INTERCEPT	1	0.01525413	0.37140137	0.04107	0.9674	
LPPA	1	0.17339076	0.13515080	1.28294	0.2054	
LPMA	1	-0.02976427	0.10070526	-0.29556	0.7688	
LPBA	1	-0.02781520	0.06357148	-0.43754	0.6636	
LKWHINS	1	0.90564577	0.03070324	29.49675	0.0001	

TEST:TEST011						
NUMERATOR:	0.01619302	DF:	3	F VALUE:	0.7090
DENOMINATOR:	0.02283827	DF:	50	PROB > F:	0.5512

Table C-17. Model D, Regression for Group I, Base Period (Average Day, July - September, 1976)

MODEL: OL DEP VARIABLE=LKWHBASE

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	21.543107	5.385777	93.928	0.0001
ERROR	50	2.866986	0.057340		
CORRECTED TOT	54	24.410092	0.452039		RSQUARE = 0.8825

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
INTERCEPT	1	-0.35230264 0.5505	0.58607112	-0.60113
LPPA	1	0.26842962 0.2146	0.21357130	1.25686
LPMA	1	-0.09942960 0.5382	0.16040116	-0.61988
LPBA	1	0.01029603 0.9189	0.10060185	0.10234
LKWHBSS	1	0.95782381 0.0001	0.05279507	18.14230

TEST:TEST012	NUMERATOR:	0.05612910	DF:	3	F VALUE:	0.9789
	DENOMINATOR:	0.05733971	DF:	50	PROB > F:	0.4102

Table C-18. Model X, Regression for Group I, Peak Period (Average Day, July - September, 1976)

MODEL: P DEP VARIABLE=LKWHPKS

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	22.817759	2.535307	10.133	0.0001
ERROR	45	11.258812	0.250196		
CORRECTED TOT	54	34.076571	0.631048		RSQUARE = 0.6696

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0	PROB > |T|
INTERCEPT	1	-2.52128017	3.53815755	-0.71260	0.4798
YUMA	1	0.34301617	0.24086944	1.42408	0.1613
KIDS	1	-0.18862279	0.21483474	-0.87799	0.3846
NOHOME	1	-0.09679717	0.25553466	-0.37880	0.7066
LWATT	1	0.31580691	0.07598537	4.15615	0.0001
LNUHHMEM	1	0.45293772	0.21651247	2.09197	0.0421

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0	PROB > |T|
LINCOME	1	0.16904962	0.11236191	1.50451	0.1394
LAGEHM	1	-0.19567989	0.11665623	-1.67741	0.1004
LCDD5	1	0.06990895	0.01527698	4.57610	0.0001
LPWH5	1	-0.85390500	2.86593374	-0.29795	0.7671

Table C-19. Model X, Regression for Group I, Intermediate Period (Average Day, July - September, 1976)

MODEL: Q DEP VARIABLE=LKWHINS

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	17.805405	1.978378	10.116	0.0001
ERROR	45	8.800604	0.195569		
CORRECTED TOT	54	26.606009	0.492704		RSQUARE = 0.6692

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
INTERCEPT	1	-1.36419395 0.6048	3.12814680	-0.43610
YUMA	1	0.28409610 0.1889	0.21295688	1.33405
KIDS	1	-0.16078136 0.4018	0.18993914	-0.84649
NOHOME	1	-0.05048462 0.8242	0.22592265	-0.22346
LWATT	1	0.28784143 0.0001	0.06717999	4.28463
LNOHHMEM	1	0.41363243 0.0361	0.19142245	2.16084
LINCOME	1	0.17382763 0.0870	0.09934112	1.74981

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
LAGEHM	1	-0.14172404 0.1762	0.10313780	-1.37412
LCDD5	1	0.05628821 0.0001	0.01350665	4.16745
LPWH5	1	-0.82827371 0.7453	2.53382200	-0.32689

Table C-20. Model X, Regression for Group I, Base Period (Average Day, July - September, 1976)

MODEL: R   DEP VARIABLE=LKWHBSS

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	13.686487	1.520721	7.856	0.0001
ERROR	45	8.710597	0.193569		
CORRECTED TOT	54	22.397084	0.414761		RSQUARE = 0.6111

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0	PROB > |T|	LABEL
INTERCEPT	1	-4.05840015	3.11210927	-1.30407	0.1988	
YUMA	1	-0.06228261	0.21186508	-0.29397	0.7701	
KIDS	1	-0.07066400	0.18896535	-0.37395	0.7102	
NOHOME	1	-0.23490613	0.22476438	-1.04512	0.3015	
LWATT	1	0.28483874	0.06683557	4.26178	0.0001	
LNOHHMEM	1	0.45582224	0.19044106	2.39351	0.0209	
LINCOME	1	0.16165930	0.09883181	1.63570	0.1089	
LAGEHM	1	-0.05772006	0.10260903	-0.56252	0.5766	

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0	PROB > |T|	LABEL
LCDDS	1	0.04098492	0.01343740	3.05006	0.0038	
LPWHS	1	-2.71428761	2.52083148	-1.07674	0.2873	

Table C-21. Model C, Regression for Group II, Peak Period (Average Day, July - September, 1976)

MODEL: OL. DEP VARIABLE=LKWHPEAK

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	8.548309	0.712359	2.455	0.1652
ERROR	5	1.450570	0.290114		
CORRECTED TOT	17	9.998880	0.588169		RSQUARE = 0.8549

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
INTERCEPT	1	-8.24107498 / 0.6551	17.36588568	-0.47456
LPPA	1	-0.78150006 / 0.7003	1.91613843	-0.40785
LPMA	1	-0.59250310 / 0.8290	2.60373127	-0.22756
LPRA	1	0.59099807 / 0.7605	1.86006454	0.32203

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
YUMA	1	0.42004343 / 0.4648	0.53109991	0.79089
KIDS	1	-0.33931320 / 0.5142	0.48355655	-0.70170
NOHOME	1	0.93698145 / 0.2142	0.65879835	1.42226
LWATT	1	0.97834131 / 0.0425	0.36172240	2.70467
LNOHHMEN	1	-0.28211156 / 0.5509	0.44146522	-0.63903
LINCOME	1	-0.24442712 / 0.5854	0.41947327	-0.58270
LPWH6	1	-4.13702242 / 0.7067	10.38025962	-0.39855
LCDD6	1	0.13982467 / 0.0901	0.06667165	2.09721
LAGEHM	1	0.26953649 / 0.4869	0.35927651	0.75022

TEST:TEST004 NUMERATOR: 0.01678535 DF: 3 F VALUE: 0.0579

DENOMINATOR: 0.29011409 DF: 5 PROB > F: 0.9798

Table C-22. Model C, Regression for Group II, Intermediate Period (Average Day, July - September, 1976)

MODEL: EL   DEP VARIABLE=LKWHINTR

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	8.777499	0.731458	3.969	0.0692
ERROR	5	0.921529	0.184306		
CORRECTED TOT	17	9.699028	0.570531	RSQUARE = 0.9050	

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0	PROB > |T|	LABEL
INTERCEPT	1	-9.88868324	13.84146703	-0.71442	0.5069	
LPPA	1	-0.82973233	1.52725679	-0.54328	0.6103	
LPMA	1	-0.33448162	2.07530219	-0.16117	0.8783	
LPBA	1	0.69496565	1.48256314	0.46876	0.6590	
YUMA	1	0.22218918	0.42331281	0.52488	0.6221	
KIDS	1	-0.53941154	0.38541841	-1.39955	0.2205	
NOHOME	1	1.03315769	0.52509476	1.96756	0.1063	
LWATT	1	1.04881118	0.28831059	3.63778	0.0149	
LNUHHMEM	1	-0.20792863	0.35186955	-0.59093	0.5803	
LINCOME	1	-0.28373720	0.33434087	-0.84865	0.4348	
LPWH6	1	-5.23715329	8.27357867	-0.63300	0.5546	
LCDD6	1	0.13063598	0.05314059	2.45831	0.0573	
LAGEHM	1	0.20552380	0.28636109	0.71771	0.5051	

TEST:TEST005 NUMERATOR: 0.02949912 DF: 3 F VALUE: 0.1
601

DENOMINATOR: 0.18430588 DF: 5 PROB > F: 0.9

188

Table C-23. Model C, Regression for Group II, Base Period (Average Day, July - September, 1976)

MODEL: FL DEP VARIABLE=LKWHBASE

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	7.610321	0.634193	2.488	0.1616
ERROR	5	1.274475	0.254895		
CORRECTED TOT	17	8.884796	0.522635	RSQUARE =	0.8566

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
INTERCEPT	1	-12.45866708 0.4786	16.27770309	-0.76538
LPPA	1	0.79664911 0.6759	1.79606920	0.44355
LPHA	1	1.17996833 0.6492	2.44057605	0.48348
LPBA	1	-0.84536754 0.6483	1.74350902	-0.48487
YUMA	1	0.14412791 0.7838	0.49782008	0.28952
KIDS	1	-0.44451681 0.3718	0.45325588	-0.98072
NOHOME	1	0.52166763 0.4368	0.61751667	0.84478
LWATT	1	0.86269973 0.0516	0.33905612	2.54442
LNOHHMEM	1	0.25586848 0.5634	0.41380209	0.61834
LINCOME	1	-0.14661074 0.7245	0.39318820	-0.37288
LPWH6	1	-4.26364349 0.6795	9.72981093	-0.43820
LCDD6	1	0.06246470 0.3634	0.06249386	0.99953

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
LAGEHM	1	0.04435720 0.9003	0.33676350	0.13172

TEST:TEST006 NUMERATOR: 0.02186761 DF: 3 F VALUE: 0.0
658
DENOMINATOR: 0.25489493 DF: 5 PROB > F: 0.9
648

Table C-24. Model D, Regression for Group II, Peak Period (Average Day, July - September, 1976)

MODEL: ML   DEP VARIABLE=LKWHPEAK

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	9.090874	2.272718	32.539	0.0001
ERROR	13	0.908006	0.069847		
CORRECTED TOT	17	9.998880	0.588169	RSQUARE = 0.9092	

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
INTERCEPT	1	1.45948774 0.5610	2.44608807	0.59666
LPPA	1	-0.74017424 0.3219	0.71882878	-1.02969
LPMA	1	-0.32848006 0.7292	0.92855848	-0.35375
LPBA	1	0.39684926 0.5399	0.63035251	0.62957
LKWHPK5	1	1.09514914 0.0001	0.10000619	10.95081

TEST:TEST007 NUMERATOR: 0.04124621 DF: 3 F VALUE: 0.5
905
DENOMINATOR: 0.06984661 DF: 13 PROB > F: 0.6
320

Table C-25. Model D, Regression for Group II, Intermediate Period (Average Day, July - September, 1976)

MODEL: NL DEP VARIABLE=LKWHINTR

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	8.588226	2.147057	25.128	0.0001
ERROR	13	1.110802	0.085446		
CORRECTED TOT	17	9.699028	0.570531		RSQUARE = 0.8855

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0	PROB > |T|	LABEL
INTERCEPT	1	0.33301177	2.71924640	0.12246	0.9044	
LPPA	1	-0.28508617	0.79630543	-0.35801	0.7261	
LPMA	1	-0.06064570	1.02573891	-0.05912	0.9538	
LPBA	1	0.23244834	0.69633693	0.33382	0.7438	
LKWHINS	1	1.05879302	0.10885397	9.72673	0.0001	

TEST:TEST008 701	NUMERATOR:	0.01453053	DF:	3	F VALUE:	0.1
147	DENOMINATOR:	0.08544628	DF:	13	PROB > F:	0.9

Table C-26. Model D, Regression for Group II, Base Period (Average Day, July - September, 1976)

MODEL: OL DEP VARIABLE=LKWHBASE

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	8.317183	2.079296	47.622	0.0001
ERROR	13	0.567612	0.043662		
CORRECTED TOT	17	8.884796	0.522635		RSQUARE = 0.9361

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
INTERCEPT	1	-1.62043890 0.4167	1.93158305	-0.83892
LPPA	1	0.28882215 0.6202	0.56896123	0.50763

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
LPMA	1	0.42019647 0.5756	0.73180903	0.57419
LPBA	1	-0.17439827 0.7320	0.49846255	-0.34987
LKWHBSS	1	1.11481591 0.0001	0.08109149	13.74763

TEST:TEST009						
	NUMERATOR:	0.01573013	DF:	3	F VALUE:	0.3603
	DENOMINATOR:	0.04366249	DF:	13	PROB > F:	0.7827

Table C-27. Model X, Regression for Group II, Peak Period (Average Day, July - September, 1976)

MODEL: P   DEP VARIABLE=LKWHPKS

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	5,936006	0.659556	4.052	0.0307
ERROR	8	1,302234	0.162779		
CORRECTED TOT	17	7.238240	0.425779	RSQUARE = 0.8201	

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	LABEL	T FOR H0:B=0
INTERCEPT	1	-7.45110021	0.3039	6.78218508		-1.09863
YUMA	1	0.35038568	0.3046	0.31946204		1.09680
KIDS	1	-0.07888671	0.7920	0.28922373		-0.27275
NOHOME	1	0.56804678	0.2291	0.43621663		1.30221
LWATT	1	0.68740237	0.0187	0.23392060		2.93861
LNOHHMEM	1	-0.36897659	0.2732	0.31360012		-1.17659
LINCOME	1	-0.05063501	0.8392	0.24150570		-0.20966
LAGEHM	1	0.12494284	0.6293	0.24896369		0.50185
LCDDS	1	0.13573970	0.0403	0.05554911		2.44360
LPWHS	1	-3.07722062	0.5677	5.16437208		-0.59586

Table C-28. Model X, Regression for Group II, Intermediate Period (Average Day, July - September, 1976)

MODEL: 0 DEP VARIABLE=LKWHINS

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	6.024312	0.669368	3.586	0.0430
ERROR	8	1.493439	0.186680		
CORRECTED TOT	17	7.517751	0.442221	RSQUARE = 0.8013	

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	LABEL	T FOR H0:B=0
INTERCEPT	1	-8.54837221	0.2730	7.26304781		-1.17697
YUMA	1	0.36174050	0.3212	0.34211218		1.05737
KIDS	1	0.00704577	0.9824	0.30972994		0.02275
NOHOME	1	0.43994961	0.3739	0.46714476		0.94178
LWATT	1	0.60894146	0.0411	0.25050577		2.43085
LNOHHMEM	1	-0.24417031	0.4879	0.33583464		-0.72706
LINCOME	1	-0.00765307	0.9771	0.25862866		-0.02959
LAGEHM	1	0.15352364	0.5806	0.26661543		0.57582
LCDD5	1	0.13223123	0.0569	0.05948759		2.22284
LPWH5	1	-4.31591330	0.4576	5.53053049		-0.78038

Table C-29. Model X, Regression for Group II, Base Period (Average Day, July - September, 1976)

MODEL: R DEP VARIABLE=LKWHBSS

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	5.409557	0.601062	3.752	0.0380
ERROR	8	1.281657	0.160207		
CORRECTED TOT	17	6.691214	0.393601	RSQUARE =	0.8085

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
INTERCEPT	1	-5.61973463 0.4278	6.72838858	-0.83523
YUMA	1	0.11731062 0.7209	0.31692806	0.37015
KIDS	1	-0.31925956 0.2982	0.28692960	-1.11268
NOHOME	1	0.31095506 0.4929	0.43275654	0.71855
LWATT	1	0.62128976 0.0280	0.23206514	2.67722
LNOHHMEM	1	0.17505015 0.5891	0.31111264	0.56266
LINCOME	1	-0.11790706 0.6359	0.23959007	-0.49212
LAGEHM	1	-0.00693281 0.9783	0.24698890	-0.02807
LCDDS	1	0.08247548 0.1729	0.05510849	1.49660
LPWHS	1	-2.98413653 0.5763	5.12340813	-0.58245

Table C-30. Model C, Regression for Group III, Peak Period (Average Day, July - September, 1976)

MODEL: DL   DEP VARIABLE=LKWHPEAK

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	5.561998	0.463500	1.869	0.1319
ERROR	14	3.471200	0.247943		
CORRECTED TOT	26	9.033197	0.347431	RSQUARE = 0.6157	

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	T FOR H0:B=0	LABEL
INTERCEPT	1	1.98389264	0.8875	13.77642670	0.14401	
LPPA	1	0.12758634	0.8145	0.53357272	0.23912	
LPMA	1	-0.30935197	0.8335	1.44480985	-0.21411	
LPBA	1	-0.14627043	0.8013	0.57038067	-0.25644	

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	T FOR H0:B=0	LABEL
YUMA	1	-0.15627954	0.6428	0.32966436	-0.47406	
KIDS	1	0.14249925	0.7718	0.48200261	0.29564	
NOHOME	1	-0.23041777	0.6340	0.47336262	-0.48677	
LWATT	1	0.07440458	0.5540	0.12270918	0.60635	
LNOHHMEM	1	0.20726634	0.5523	0.34039547	0.60890	
LINCOME	1	0.31581133	0.1944	0.23171561	1.36293	
LPWH6	1	0.80382046	0.9412	10.70347191	0.07510	
LCDD6	1	0.03611842	0.2453	0.02978054	1.21282	
LAGEHM	1	-0.11497846	0.5522	0.18877167	-0.60909	

TEST:TEST004   NUMERATOR: 0.04242141   DF: 3   F VALUE: 0.1711

DENOMINATOR: 0.24794283   DF: 14   PROB > F: 0.9141

Table C-31. Model C, Regression for Group III, Intermediate Period (Average Day, July - September, 1976)

MODEL: EL   DEP VARIABLE=LKWHINTR

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	5.492174	0.457681	1.718	0.1663
ERROR	14	3.730547	0.266468		
CORRECTED TOT	26	9.222721	0.354720		RSQUARE = 0.5955

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0	PROB > |T|	LABEL
INTERCEPT	1	5.91899031	14.28180370	0.41444	0.6848	
LPPA	1	0.36267245	0.55314640	0.65565	0.5227	
LPMA	1	0.49322594	1.49781152	0.32930	0.7468	
LPBA	1	-0.33237302	0.59130462	-0.56210	0.5829	
YUMA	1	-0.06703648	0.34175783	-0.19615	0.8473	
KIDS	1	0.16106581	0.49968448	0.32234	0.7520	
NUHOME	1	-0.20765621	0.49072754	-0.42316	0.6786	
LWATT	1	0.12398776	0.12721066	0.97466	0.3463	
LNOHHMEM	1	0.18279244	0.35288260	0.51800	0.6125	
LINCOME	1	0.16738023	0.24021591	0.69679	0.4973	
LPAHG	1	4.60068686	11.09612007	0.41462	0.6847	
LCDD6	1	0.03241185	0.03087302	1.04984	0.3116	
LAGEHM	1	-0.15096972	0.19569660	-0.77145	0.4533	

TEST:TEST005 NUMERATOR: 0.04372437 DF: 3 F VALUE: 0.1
041

188 DENOMINATOR: 0.26646766 DF: 14 PROB > F: 0.9

Table C-32. Model C, Regression for Group III, Base Period (Average Day, July - September, 1976)

MODEL: FL   DEP VARIABLE=LKWHBASE

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	12	5.665707	0.472142	1.767	0.1542
ERROR	14	3.741450	0.267246		
CORRECTED TOT	26	9.407157	0.361814	RSQUARE =	0.6023

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	LABEL	T FOR H0:B=0
INTERCEPT	1	-7.71441870	0.5981	14.30265864		-0.53937
LPPA	1	-0.09595249	0.8650	0.55395413		-0.17321
LPMA	1	0.16946855	0.9117	1.49999869		0.11298
LPBA	1	-0.02795886	0.9630	0.59216807		-0.04721
YUMA	1	0.05920572	0.8651	0.34225688		0.17299
KIDS	1	0.10519908	0.8365	0.50041414		0.21022
NOHOME	1	-0.38488001	0.4466	0.49144412		-0.78316
LWATT	1	0.07871109	0.5466	0.12739642		0.61784
LNOHHMEM	1	0.22675982	0.5315	0.35339790		0.64166
LINCOME	1	0.31259125	0.2148	0.24056668		1.29940
LPWH6	1	-6.60806744	0.5616	11.11232312		-0.59466
LCDD6	1	0.01067018	0.7351	0.03091810		0.34511

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	LABEL	T FOR H0:B=0
LAGEHM	1	-0.11329032	0.5724	0.19598237		-0.57806

TEST:TEST006 NUMERATOR: 0.00655952 DF: 3 F VALUE: 0.0
245
DENOMINATOR: 0.26724645 DF: 14 PROB > F: 0.9
946

Table C-33. Model D, Regression for Group III, Peak Period (Average Day, July - September, 1976)

MODEL: ML DEP VARIABLE=LKWHPEAK

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	8.595394	2.148848	107.981	0.0001
ERROR	22	0.437804	0.019900		
CORRECTED TOT	26	9.033197	0.347431	RSQUARE = 0.9515	

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
INTERCEPT	1	0.52906275 0.1687	0.37175262	1.42316
LPPA	1	-0.03163540 0.7663	0.10512073	-0.30094
LPMA	1	-0.21946483 0.4578	0.29036642	-0.75582
LPGA	1	0.04443326 0.6710	0.10317628	0.43057
LKWHPKS	1	0.92313396 0.0001	0.04673200	19.75379

TEST:TEST007	NUMERATOR:	0.00465514	DF: 3	F VALUE:	0.2339
	DENOMINATOR:	0.01990017	DF: 22	PROB > F:	0.8717

Table C-34. Model D, Regression for Group III, Intermediate Period (Average Day, July - September, 1976)

MODEL: NL DEP VARIABLE=LKWHINTR

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	8.504163	2.126041	65.093	0.0001
ERROR	22	0.718558	0.032662		
CORRECTED TOT	26	9.222721	0.354720		RSQUARE = 0.9221

SOURCE	DF	B VALUE	STD DEVIATION	T FOR H0:B=0
		PROB > |T|	LABEL	
INTERCEPT	1	0.38096584	0.46422137	0.82066
		0.4206		
LPPA	1	0.02246274	0.13521126	0.16613
		0.8696		
LPMA	1	0.31799205	0.37123072	0.85659
		0.4009		
LPBA	1	-0.06190438	0.13197623	-0.46906
		0.6436		
LKWHINS	1	0.83330209	0.05665751	14.70771
		0.0001		

TEST:TEST008	NUMERATOR:	0.00878417	DF:	3	F VALUE:	0.2
689	DENOMINATOR:	0.03266174	DF:	22	PROB > F:	0.8
471						

Table C-35. Model D, Regression for Group III, Base Period (Average Day, July - September, 1976)

MODEL: OL DEP VARIABLE=LKWHBASE

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	4	8.759350	2.189838	74.368	0.0001
ERROR	22	0.647807	0.029446		
CORRECTED TOT	26	9.407157	0.361814		RSQUARE = 0.9311

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
INTERCEPT	1	-0.03681072 0.9351	0.44677933	-0.08239
LPPA	1	0.12315195 0.3424	0.12690809	0.97040

SOURCE	DF	B VALUE PROB > |T|	STD DEVIATION LABEL	T FOR H0:B=0
LPMA	1	-0.04386008 0.9048	0.36253555	-0.12098
LPBA	1	0.10058722 0.4347	0.12641898	0.79567
LKWHBS5	1	0.96509678 0.0001	0.06193914	15.58137

TEST:TEST009	NUMERATOR:	0.03064721	DF:	3	F VALUE:	1.0408
	DENOMINATOR:	0.02944578	DF:	22	PROB > F:	0.3941

Table C-36. Model X, Regression for Group III, Peak Period (Average Day, July - September, 1976)

MODEL: P DEP VARIABLE=LKWHPK5

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	6.724060	0.747118	3.490	0.0128
ERROR	17	3.639706	0.214100		
CORRECTED TOT	26	10.363766	0.398606		RSQUARE = 0.6488

SOURCE	DF	B VALUE	PROB > ¦T¦	STD DEVIATION	LABEL	T FOR H0:B=0
INTERCEPT	1	-3.89812968	0.4141	4.65651607		-0.83713
YUMA	1	-0.06243026	0.8116	0.25782900		-0.24214
KIDS	1	0.01500932	0.9617	0.30817779		0.04870
NOHOME	1	-0.38434041	0.3190	0.37435307		-1.02668
LWATT	1	0.03776508	0.7309	0.10799284		0.34970
LNOHHMEM	1	0.27011140	0.2774	0.24072722		1.12206
LINCOME	1	0.28543309	0.1621	0.19530362		1.46148
LAGEHM	1	-0.24899526	0.1459	0.16337335		-1.52409
LCDD5	1	0.03327224	0.4019	0.03870236		0.85970
LPWH5	1	-4.66751165	0.1912	3.42899852		-1.36119

Table C-37. Model X, Regression for Group III, Intermediate Period (Average Day, July - September, 1976)

MODEL: 0 DEP VARIABLE=LKWHINS

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	6.815477	0.757275	2.615	0.0420
ERROR	17	4.923212	0.289601		
CORRECTED TOT	26	11.738689	0.451488	RSQUARE = 0.5806	

SOURCE	DF	B VALUE / PROB > |T|	STD DEVIATION / LABEL	T FOR H0:B=0
INTERCEPT	1	-3.76428718 0.4964	5.41567289	-0.69507
YUMA	1	-0.05423017 0.8586	0.29986301	-0.18085
KIDS	1	0.01699029 0.9627	0.35842020	0.04740
NOHOME	1	-0.40657273 0.3635	0.43538407	-0.93383
LWATT	1	0.03436120 0.7877	0.12559898	0.27358
LNOHHMEM	1	0.17579173 0.5384	0.27997312	0.62789
LINCOME	1	0.35358714 0.1380	0.22714409	1.55666
LAGEHM	1	-0.21826631 0.2666	0.19000820	-1.14872
LCDDS	1	0.04458657 0.3358	0.04501203	0.99055
LPWHS	1	-3.33555964 0.4145	3.98803013	-0.83639

Table C-38. Model X, Regression for Group III, Base Period (Average Day, July - September, 1976)

MODEL: R   DEP VARIABLE=LKWHBS5

SOURCE	DF	SS	MEAN SQUARE	F RATIO	PROB > F
REGRESSION	9	6.184515	0.687168	4.125	0.0058
ERROR	17	2.832153	0.166597		
CORRECTED TOT	26	9.016667	0.346795	RSQUARE = 0.6859	

SOURCE	DF	B VALUE	PROB > |T|	STD DEVIATION	T FOR H0:B=0
INTERCEPT	1	-8.50821818	0.0539	4.10758406	-2.07134
YUMA	1	-0.22132045	0.3441	0.22743480	-0.97312
KIDS	1	0.15196477	0.5834	0.27184823	0.55901
NOHOME	1	-0.04346307	0.8968	0.33022243	-0.13162
LWATT	1	0.03346959	0.7296	0.09526210	0.35134
LNUHHMEM	1	0.25893990	0.2393	0.21234907	1.21941
LINCOME	1	0.34504303	0.0614	0.17228024	2.00280
LAGEHM	1	-0.14509710	0.3281	0.14411407	-1.00682
LCDDS	1	0.01674802	0.6300	0.03413993	0.49057
LPWHS	1	-7.21070224	0.0291	3.02477075	-2.38388

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APPENDIX D: ELECTRICITY DEMAND UNDER CONSUMER BUDGETING USING THE TRANSLOG MODEL

This appendix presents an alternative response surface estimation approach that is based on more assumptions than that of chapter 4. Specifically, it assumes that consumers allocate their income in two stages: first, into broad categories such as electricity and other goods and, second, into subcategories within the broad categories such as expenditures on peak and base period electricity. It also assumes certain mathematical restrictions on the empirical approximations to a "representative" individual's preference function, e.g., homotheticity which implies that expenditure (budget) shares on individual commodities do not change when an individual's income changes.

Section D.1 presents the essence of the two-stage budgeting approach and its implications for applied demand analysis. Section D.2 presents one empirical model that assumes this two-stage budgeting approach and another that does not. Both are derived from transcendental logarithmic (translog) approximations of the relevant preference functions for the "representative" individual. Finally section D.3 presents the empirical results from the estimation of the models of section D.2.

The main finding reported in this appendix is that differences among households in marginal KWH prices do appear, in the most restrictive model, to account for a significant amount of the variation among KWH consumption among households <u>but</u> that these apparent relationships are probably spurious due to the overly restrictive nature of the estimation model. Furthermore, we conclude that any elasticity estimates developed under the second stage of the two-stage budgeting approach must be augmented by independent estimates of other parameters to obtain defensible elasticity estimates.

D.1 The Two-Stage Budgeting Approach

One approach to modeling electricity demand is to follow the branchwise budgeting and utility tree concept developed by Strotz (1957) and Gorman (1959). Under this approach the individual consumer is assumed to optimize the commodity allocation of his income (maximize his utility) in stages. For example, in the simplest case, the consumer may choose in two stages among the set of n commodities denoted by N:* $N = (q_1,\ldots,q_n)$. First, the consumer is assumed to partition the set N into a class of mutually exclusive and exhaustive subsets or budget categories, $(N_1,\ldots,N_S)$. Therefore

$$N = N_1 \cup \ldots \cup N_S \text{ and } N_s \cap N_t \text{ is empty for } s \neq t.$$

The consumer then allocates his income, y, to these commodity groups, thereby determining the level of expenditure, m_k, on each of the S commodity groups. In the second stage the group expenditure, m_k, is allocated to the n_k commodities in the kth commodity group.†

The first-stage group expenditure equations are given by

$$m_k = m_k(P_1,\ldots,P_S,y)$$

where $k=1,\ldots,S$, $\sum_{k=1}^{S} m_k = y$, and $P_k = P_k(p(k)_1,\ldots,p(k)_{n_k})$.

The P_k are group price indexes that are functions only of the prices, $p(k)_i$, of the commodities in the corresponding subset.

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*The notation used here closely follows that used in Goldman and Uzawa (1964).

†Since the kth subset contains n commodities $n = \sum_{k=1}^{S} n_k$.

The second-stage demand equations are

$$q(k)_j = h(p(k)_1,\ldots,p(k)_{n_k},m_k), \quad j=1,\ldots,n_k,\; k=1,\ldots,S$$

$$\text{with } m_k = \sum_{j=1}^{n_k} p(k)_j q(k)_j.$$

Following Bieri and de Janvry (1972) the complete reduced-form demand equations for individual commodities, after maximization in two stages, are referred to as the "two-stage" demand equations and are given by

$$q(k)_j = g[p(k)_1,\ldots,p(k)_{n_k},m_k(P_1,\ldots,P_S,y)].$$

Therefore the complete differentials of commodity consumption with respect to prices and income are

$$dq(k)_i/dp(k)_j = \partial q(k)_i/\partial p(k)_j \Big|_{dm_k=0} + (\partial q(k)_i/\partial m_k)(dm_k/dp(k)_j), \qquad \text{(D-1)}$$

$$dq(k)_i/dp(\ell)_j = (\partial q(k)_i/\partial m_k)\,(dm_k/dp(\ell)_j), \text{ for } N_k \neq N_\ell \text{, and} \qquad \text{(D-2)}$$

$$dq(k)_i/dy = (\partial q(k)_i/\partial m_k)\,(\partial m_k/\partial y). \qquad \text{(D-3)}$$

Equation (D-1) can be used directly to obtain an expression for the "total" own- and cross-price elasticities of demand for products within the k<u>th</u> group. By first multiplying (D-1) through by $p(k)_j/q(k)_i$ and then manipulating terms it is easily shown that

$$E(k)_{ij} = E(k)^*_{ij} + d(k)_i \, b(k)_j \qquad (D\text{-}4)$$

where

$E(k)_{ij} = d\ln q(k)_i / d\ln p(k)_j$ = "total" price elasticities of demand,

$E(k)^*_{ij} = \partial \ln q(k)_i / \partial \ln p(k)_j \Big|_{dm_k=0}$ = "partial" price elasticities of demand,

$d(k)_i = \partial \ln q(k)_i / \partial \ln m_k$ = demand elasticities with respect to intra-group expenditures, and

$b(k)_j = d\ln m_k / d\ln p(k)_j$ = intra-group expenditure elasticities.

for q_i, $q_j \in N_k$.

Also equation (D-2) can be multiplied through by $p(\ell)_j/q(k)_i$ and manipulated to state

$$E(k)_{ij} = d(k)_i b(k)_j$$

for $q_i \in N_k$ and $q_j \in N_\ell$ where $\ell \neq k$.

Finally equation (D-3) can be multiplied through by $y/q(k)_i$ and manipulated to state

$$e(k)_i = d(k)_i c_k$$

where $e(k)_i = d\ln q(k)_i / d\ln y$ = income elasticity of demand and

$c_k = d\ln m_k / d\ln y$ = income elasticity of group expenditure.

Alternatively Bieri and de Janvry (1972, p. 26) have shown that equation (D-1) can be restated as

$$E(k)_{ij} = E(k)^{*}_{ij} + a(k)_j h_k e(k)_i (h_k^{-1} - c_k)(1-w^{-1} e(k)_j c_k) \quad \text{(D-5)}$$

where $a(k)_j = p(k)_j q(k)_j / m_k$ = intra-group budget shares,

$h_k = m_k / y$ = group budget shares, and

w = "flexibility of money" or the income elasticity of the marginal utility of income.

D.2 Estimation Models

An alternative to the demand models of chapter 4 is to adopt a particular functional form for a representative customer's utility (preference) function and then to derive the appropriate corresponding functional forms for the first-order conditions. Unfortunately this approach exacts a high cost. First, of the widely mentioned functional forms for utility functions, there are very few that do not imply some type of separability and, at the same time, yield easily estimable (intrinsically linear) demand functions.* Separability is clearly an undesirable restriction when very closely related goods (such as electricity consumed at different times of day) are involved. Secondly, among those utility functions that do not imply separability it is necessary either to impose, a priori, other restrictions based on demand theory, e.g., homotheticity, to achieve intrinsic linearity in the estimation model or to estimate highly nonlinear models. Among this latter group of utility functions, which includes the quadratic and generalized Leontief utility functions, the transcendental logarithmic (translog) utility function has achieved popularity because of its relative convenience (Christensen, et al., 1975). Since one interpretation of this model has

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*Separability means that the ratio of a consumer's marginal utility (satisfaction) from consuming two goods is unaffected by a change in the consumption of a third (Bieri and deJanvry, 1972).

already been applied by others to the Arizona project data and since it provides an interesting comparison to the models of chapter 4, it is chosen here as an alternative model.

Since extensive details about the translog model are given in the reference cited above and since nonlinear versions of the models were not estimated in this study, the actual intrinsically linear estimation forms of the model are directly stated here. It is critical to note, though, that these and all other intrinsically linear forms of the translog model require the imposition of both the homotheticity and homogeneity restrictions as defined by Christensen, et al. (1975, p. 372).

Two versions of the translog model are hypothesized. The first, referred to hereafter as the 3-good model imposes weak separability, a la Gorman (1959) and Strotz (1957), between the consumer's budget for electricity and that for other goods (as discussed in section D.1). The second, referred to as the 4-good model, relaxes this separability assumption. The purpose of hypothesizing both models is to isolate the effect of the separability assumption from the effects of the other assumptions (homogeneity and homotheticity) on the resulting elasticity estimates.

The general form of the translog model to be estimated is

$$s_i = a_i + \sum_{j=1}^{m} b_{ij}x_j + \sum_{k=1}^{9-m} g_{ik}z_k + e \qquad \text{(D-5)}$$

where

$$s_i = p_i q_i / M \text{ and}$$

3-Good Model:

x_i = $\ln(p_i/M)$ for the three-good model ($m=3$ and $i=1,2,3$), and

s_i = $p_i q_i/Y$, and

4-Good Model:

x_i = $\ln(p_i/Y)$ for the four-good model ($m=4$ and $i=1,\ldots,4$) where

q_i = KWH consumption during period i for $i=1,2,3$ and consumption of all other goods for $i=4$,

p_i = marginal price per KWH in the peak, intermediate, and base rating periods for $i=1,2,3$, respectively, and a constant (the average price of all other goods is assumed constant in the small geographic cross-section of the study) for $i=4$,

M = "quasi" electricity expenditures = $\Sigma p_i q_i$,

Y = family income

z_k defined in table 4-1,

a_i, b_{ij}, g_{ik} = regression coefficients, and

e = error term.

Due to the budget restriction only two of the three equations need to be estimated in the three-good model and only three of the four in the four-good model. Further, under homogeneity, the parameters of the remaining equation can be computed from the relationships

$$\Sigma a_i = 1 \quad \text{and}$$

$$\Sigma b_{ij} = 0 \text{ for } j=1,\ldots,m$$ ($m=3$ for the 3-good model and $m=4$ for the 4-good model).

The models of (D-6) can also be estimated by imposing and simultaneously testing the major restriction implied by neoclassical demand theory, viz., the symmetry restriction that

$$b_{ij} = b_{ji}.$$

The simultaneous imposition of the homotheticity and homogeniety restrictions can be shown to imply that the own- and cross-price elasticities of demand are estimated by

$$n_{ii} = -1 + b_{ii}/s_i \quad \text{for } i=1,\ldots,m$$

$$n_{ij} = b_{ij}/s_i \quad \text{for } i,j=1,\ldots,m \text{ and } i=j.$$

Once again the variances of the estimated elasticities are linear functions of means. It can easily be shown that this results in t-values for the own-price elasticities that are generally smaller than those associated with the corresponding own-price coefficients; but they are the same for the cross-price elasticities as for the cross-price coefficients.

Unfortunately, it is also true, under these restrictions, that elasticities of electricity demand with respect to electricity expenditures are unity in the three-good model, i.e., that

$$d_i = \partial \ln q_i / \partial \ln M = 1 \quad \text{for the three-good model,}$$

and that all income elasticities are unity in the four-good model, i.e., that

$$e_i = \partial \ln q_i / \partial \ln Y = 1 \text{ for the four-good model.}$$

In general the matrix of price coefficients, b_{ij}, consists of m^2 parameters. However, m restrictions are imposed by the homotheticity and homogeneity restrictions. An additional m(m-1)/2 constraints are imposed by the symmetry restrictions. Therefore only m(m-1)/2 of the price coefficients are free parameters when all restrictions are imposed. For the three-good model this implies that only three of the nine price parameters are directly estimable; and, for the four-good model, that only six of the 16 are directly estimable.

D.3 Empirical Results

The estimated translog models of equation (D-6) are useful primarily as illustrations of the potent effects of untested model restrictions, i.e., of the assumptions of separability, homogeneity, and homotheticity. As mentioned in the previous section all of the intrinsically linear versions of the translog require the simultaneous imposition of both the homotheticity restrictions and the homogeneity restriction on the underlying utility function. Both types of restrictions are necessary to insure that the translog approximation to the utility function is itself homothetic (Christensen et al., p. 372).* As was also mentioned, the so-called three-good translog model further restricts the data by imposing weak separability. Finally, the symmetry restrictions impose the main postulates of demand theory on the estimated functions.

All of the regressions of (D-6) were completed for the aggregate data (July-September) and are reported in detail in tables D-1 through D-8.†

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*The simultaneous imposition of both of those restrictions is referred to below as "explicit homotheticity."

†Since this analysis was completed after those of chapter 4 some of the independent variables used in the models of (3) were eliminated due to their relatively small contributions to the explanatory power of the models.

Tables D-1, D-2, and D-3 report detailed regression results for the 3-good model with only explicit homotheticity imposed for Groups I, II, and III, respectively. Tables D-4, D-5, and D-6 report corresponding results for the 4-good model. Table D-7 reports the simultaneously estimated coefficients of the 3-good model share equation (5) when both explicit homotheticity and symmetry are imposed; and table D-8 reports those same results for the 4-good model.

Generally, the regressions were highly significant and the R^2 were high for the "unrestricted" 3-good models.* The R^2 were somewhat lower but still generally above .6 for the "unrestricted" 4-good models. The estimated elasticities from the unrestricted models are given in table D-9. The remarkable differences in apparent statistical significance between the 3-good and the 4-good model results suggest some skepticism about the appropriateness of the separability restriction of the 3-good model.† This is particularly so in view of the virtually identical patterns of signs and lack of significance of the aggregate results in the demand models of tables 4-3 through 4-5 and those of the 4-good translog models.¶ By contrast many of the estimated "partial" elasticities of the 3-good model are highly significant. Thus it appears that <u>the differences between the translog results and</u>

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*When symmetry is imposed, along with explicit homotheticity, the estimated translog model is referred to as "restricted." Otherwise it is referred to as "unrestricted" even though explicit homotheticity is still maintained.

†Recall from equation (D-4) that the elasticity estimates from the three-good model are partial, i.e., the E* parameters, and would need to be augmented by estimates of the a and b parameters to be comparable to the estimates from the four-good models.

¶Of the 27 price elasticities that are estimated in the two types of models, the signs are different for only two (η_{32} in Group I and η_{33} in Group III). For both types of models <u>all</u> price coefficients are nonsignificant.

Table D-1. Unrestricted translog model estimates:[1]
3-good model, Group I

Estimated Coefficient	Peak Period	Intermediate Period	Base Period
a_i	0.07604 (0.81)	0.5101 (7.12)***	0.4138 (5.29)***
b_{i1}	0.1746 (7.04)***	-0.1418 (-7.52)***	-0.03281 (-1.60)
b_{i2}	-0.1940 (-8.85)***	0.2285 (13.72)**	-0.03445 (-1.90)*
b_{i3}	-0.01546 (-0.89)	-0.08336 (-6.34)***	0.09882 (6.89)***
g_{i1}	0.02826 (1.25)	-0.01078 (-0.63)	-0.01749 (-0.93)
g_{i2}	0.07054 (3.54)***	-0.03721 (-2.46)**	-0.03333 (-2.02)**
g_{i3}	0.03371 (-2.45)**	0.005774 (0.55)	0.02794 (2.44)**
g_{i4}	-0.007153 (-0.99)	0.0004841 (0.09)	0.006669 (1.12)
g_{i5}	-0.00001571 (1.79)*	-0.00001093 (-1.64)	-0.00000478 (-0.66)
g_{i6}	-0.008648 (-0.91)	0.0004836 (0.67)	0.003812 (0.49)
SSE	0.08206	0.04740	0.05644
SST	0.42320	0.2932	0.1724
R^2	.8061	.8384	0.6727

[1]The t-value associated with each coefficient value is reported in parentheses. All significance tests are two-tailed tests against the alternative that the true values of the coefficients are zero. A single asterisk (*) denotes significance at the 10 precent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. SSE is the regression error sum of squares; SST is the regression total sum of squares.

Table D-2. Unrestricted translog model estimates:[1]
3-good model, Group II

Estimated Coefficient	Peak Period	Intermediate Period	Base Period
a_i	0.08192 (0.21)	0.5780 (1.82)	0.3400 (1.40)
b_{i1}	0.2097 (3.78)***	-0.2280 (-4.99)***	0.01826 (0.52)
b_{i2}	-0.1516 (-2.17)*	0.2417 (4.21)***	-0.0900 (-2.04)*
b_{i3}	-0.1291 (-2.36)**	0.04857 (1.08)	0.08050 (2.34)**
g_{i1}	-0.04680 (-1.09)	0.03331 (0.94)	0.01349 (0.50)
g_{i2}	0.03173 (0.76)	0.004981 (0.14)	-0.03672 (-1.39)
g_{i3}	0.007675 (0.18)	-0.04269 (-1.22)	0.03501 (1.30)
g_{i4}	-0.06293 (-1.66)	0.06176 (1.98)*	0.001163 (0.05)
g_{i5}	-0.00002532 (-0.75)	0.00003174 (1.15)	-0.00000642 (-0.30)
g_{i6}	0.02617 (0.77)	-0.01181 (-0.42)	-0.01436 (-0.67)
SSE	0.01759	0.01192	0.006999
SST	0.07207	0.06639	0.02955
R^2	.7560	.8204	.7631

[1]The t-value associated with each coefficient value is reported in parentheses. All significance tests are two-tailed tests against the alternative that the true values of the coefficients are zero. A single asterisk (*) denotes significance at the 10 precent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. SSE is the regression error sum of squares; SST is the regression total sum of squares.

Table D-3. Unrestricted translog model estimates:[1]
3-good model, Group III

Estimated Coefficient	Peak Period	Intermediate Period	Base Period
a_i	0.4174 (3.27)***	0.2406 (3.26)***	0.3420 (2.74)**
b_{i1}	0.2368 (8.5)***	-0.1204 (-7.49)***	-0.1164 (-4.29)***
b_{i2}	-0.1244 (-4.10)***	0.1458 (8.31)***	-0.02141 (-0.72)
b_{i3}	-0.1147 (-4.77)***	-0.03206 (-2.30)**	0.1468 (6.24)***
g_{i1}	0.01030 (0.35)	0.008866 (0.52)	-0.01917 (-0.66)
g_{i2}	-0.01917 (-1.18)	0.02605 (2.78)**	-0.006883 (-0.43)
g_{i3}	-0.01070 (-0.71)	-0.002504 (-0.29)	0.01320 (0.90)
g_{i4}	-0.01302 (-1.90)*	0.002704 (0.68)	0.01031 (1.54)
g_{i5}	0.00001411 (1.26)	0.00000057 (0.09)	-0.00001468 (-1.34)
g_{i6}	0.01182 (0.90)	0.008566 (-1.12)	-0.003258 (-0.25)
SSE	0.01829	0.006128	0.01749
SST	0.1647	0.04212	0.09574
R^2	.8889	.8545	.8173

[1]The t-value associated with each coefficient value is reported in parentheses. All significance tests are two-tailed tests against the alternative that the true values of the coefficients are zero. A single asterisk (*) denotes significance at the 10 precent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. SSE is the regression error sum of squares; SST is the regression total sum of squares.

Table D-4. Unrestricted translog model estimates:[1]
4-good model, Group I

Estimated Coefficient	Peak Period	Intermediate Period	Base Period
a_i	0.3606 (4.11)***	0.4094 (4.34)***	0.1461 (3.83)***)
b_{i1}	0.06797 (2.84)***	0.02920 (1.14)	0.01170 (1.12)
b_{i2}	-0.007557 (-0.46)	0.0207 (2.36)**	0.0003899 (0.05)
b_{i3}	0.0003332 (0.03)	-0.003137 (-0.27)	0.009791 (2.11)**
b_{i4}	-0.02066 (-0.78)	-0.02687 (-0.95)	-0.006953 (-0.61)
g_{i1}	-0.001126 (-0.09)	0.003605 (0.26)	-0.001638 (-0.29)
g_{i2}	0.01281 (1.16)	0.007340 (0.62)	-0.002561 (-0.53)
g_{i3}	0.01402 (1.81)*	0.007636 (0.92)	0.005561 (1.65)
g_{i4}	0.01062 (2.80)***	0.01321 (3.24)***	0.004770 (2.89)***
g_{i5}	0.00001394 (3.14)***	0.00000990 (2.07)**	0.00000351 (1.82)*
SSE	0.02607	0.03021	0.004941
SST	0.07638	0.07682	0.01294
R^2	.6587	.6068	.6181

[1]The t-value associated with each coefficient value is reported in parentheses. All significance tests are two-tailed tests against the alternative that the true values of the coefficients are zero. A single asterisk (*) denotes significance at the 10 precent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. SSE is the regression error sum of squares; SST is the regression total sum of squares.

Table D-5. Unrestricted translog model estimates:[1]
4-good model, Group II

Estimated Coefficient	Peak Period	Intermediate Period	Base Period
a_i	0.2009 (0.48)	0.2296 (0.87)	0.2237 (1.31)
b_{i1}	-0.05593 (-0.49)	-0.05160 (-0.72)	0.009370 (0.20)
b_{i2}	-0.1214 (-0.77)	-0.01530 (-0.15)	0.02212 (0.35)
b_{i3}	0.09908 (0.94)	0.06133 (0.92)	0.007731 (0.18)
b_{i4}	0.1893 (1.20)	0.07325 (0.74)	-0.006835 (-0.10)
g_{i1}	0.02489 (0.68)	0.02129 (0.91)	0.001224 (0.08)
g_{i2}	0.04238 (1.35)	0.007336 (0.37)	-0.002208 (-0.17)
g_{i3}	-0.05225 (-1.79)	-0.03586 (-1.94)*	-0.003422 (-0.29)
g_{i4}	0.06264 (4.38)***	0.04271 (4.72)***	0.01712 (2.93)**
g_{i5}	0.00004977 (2.86)**	0.00002747 (2.49)**	0.00001058 (1.49)
SSE	0.01100	0.004395	0.001827
SST	0.08843	0.03607	0.008869
R^2	.8756	.8781	.7939

[1]The t-value associated with each coefficient value is reported in parentheses. All significance tests are two-tailed tests against the alternative that the true values of the coefficients are zero. A single asterisk (*) denotes significance at the 10 precent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. SSE is the regression error sum of squares; SST is the regression total sum of squares.

Table D-6. Unrestricted translog model estimates:[1]
4-good model, Group III

Estimated Coefficient	Peak Period	Intermediate Period	Base Period
a_i	0.4392 (2.33)**	0.1855 (3.02)***	0.1101 (2.53)**
b_{i1}	0.06396 (3.18)***	0.006484 (0.99)	-0.0009204 (-0.19)
b_{i2}	-0.009679 (-0.19)	0.02565 (1.51)	0.003164 (0.26)
b_{i3}	-0.00007969 (-0.00)	-0.002680 (-0.43)	0.01228 (2.75)**
b_{i4}	-0.02130 (-0.48)	-0.01858 (-1.29)	-0.007423 (-0.72)
g_{i1}	-0.01165 (-0.56)	-0.003047 (-0.45)	-0.003959 (-0.82)
g_{i2}	-0.0007127 (-0.06)	0.002533 (0.67)	0.0001249 (0.05)
g_{i3}	0.0026675 (0.25)	0.001029 (0.29)	0.002320 (0.93)
g_{i4}	0.0026202 (0.54)	0.001029 (0.77)	0.001942 (1.74)
g_{i5}	0.00001127 (1.43)	0.00000306 (1.19)	-0.00000038 (-0.21)
SSE	0.009450	0.001002	0.000503
SST	0.02335	0.002008	0.001392
R^2	.5953	.5011	.6386

[1]The t-value associated with each coefficient value is reported in parentheses. All significance tests are two-tailed tests against the alternative that the true values of the coefficients are zero. A single asterisk (*) denotes significance at the 10 precent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. SSE is the regression error sum of squares; SST is the regression total sum of squares.

Table D-7. Restricted translog model estimates:[1] 3-good model, Groups I-III

Estimated Coefficient	Group I	Group II	Group III
a_1	-0.1861	-0.5345	-0.4254
	(-2.43)**	(-1.66)	(-5.23)***
a_2	-0.5182	0.2735	-0.2729
	(-6.84)***	(-0.82)	(-3.36)***
b_{11}	-0.1849	-0.2321	-0.2358
	(-10.33)***	(-4.60)***	(-13.45)***
b_{12}	0.1679	0.1600	0.1194
	(11.67)***	(3.89)***	(7.77)***
b_{22}	-0.2443	-0.1558	-0.1495
	(-13.96)***	(-2.81)**	(-6.92)***
g_{11}	0.03194	-0.03686	0.009849
	(1.53)	(-0.84)	(0.43)
g_{12}	0.08238	0.04473	-0.01859
	(4.64)***	(1.17)	(-1.47)
g_{13}	-0.02916	-0.03372	-0.009894
	(-2.37)**	(0.90)	(-0.86)
g_{14}	0.00186	-0.01066	-0.01295
	(0.31)	(-0.58)	(-2.46)**
g_{15}	0.00002663	0.00002649	0.00001437
	(3.70)***	(1.27)	(1.67)
g_{16}	-0.0006375	-0.009705	0.01243
	(-0.08)	(-0.32)	(1.40)
g_{21}	-0.005160	0.03518	0.005172
	(-0.25)	(0.81)	(0.23)
g_{22}	-0.03550	-0.01920	0.02665
	(-2.01)**	(-0.49)	(2.10)**
g_{23}	0.0008446	-0.02047	-0.0007301
	(0.07)	(-0.54)	(-0.06)
g_{24}	0.0003684	0.01909	0.002973
	(0.06)	(1.04)	(0.57)
g_{25}	-0.00000985	0.00000003	0.00000094
	(-1.38)	(0.00)	(0.11)
g_{26}	0.004067	-0.001035	-0.005915
	(0.50)	(-0.03)	(-0.64)
SSE	0.1442	0.0437	0.02465
SST	0.7164	0.13846	0.20682
R^2	.799	.684	.881

[1]The t-value associated with each coefficient value is reported in parentheses. All significance tests are two-tailed tests against the alternative that the true values of the coefficients are zero. A single asterisk (*) denotes significance at the 10 precent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. SSE is the regression error sum of squares; SST is the regression total sum of squares.

Table D-8. Restricted translog model estimates:[1]
4-good model, Groups I-III

Estimated Coefficient	Group I	Group II	Group III
a_1	-0.08483 (-0.86)	0.7357 (2.57)	-0.2126 (-2.80)***
a_2	-0.04125 (-0.48)	0.2975 (0.82)	-0.06282 (-0.49)
a_3	-0.09124 (-1.28)	0.01589 (0.06)	-0.06404 (-0.81)
b_{11}	-0.04221 (-1.39)	0.1019 (1.18)	-0.04278 (-2.92)***
b_{12}	0.01929 (1.11)	0.07538 (0.70)	0.007108 (0.51)
b_{22}	-0.01833 (-0.89)	-0.01205 (-0.08)	(-0.01105) (-0.28)
b_{13}	-0.01096 (-0.90)	-0.04542 (-0.66)	(-0.001713) (-0.18)
b_{23}	-0.01094 (-1.01)	-0.03600 (-0.39)	-0.002468 (-0.17)
b_{33}	-0.008353 (-0.75)	0.02840 (0.43)	-0.01141 (-0.96)
g_{11}	0.01536 (0.90)	0.06442 (1.62)	-0.01478 (-0.92)
g_{12}	0.005554 (0.38)	0.09824 (2.99)	0.002536 (0.27)
g_{13}	-0.007796 (-0.81)	-0.03801 (-1.10)	-0.006239 (-0.75)
g_{14}	0.002519 (0.52)	0.05100 (3.07)	-0.005628 (-1.66)
g_{15}	0.00000622 (1.08)	-0.00001609 (-1.46)	0.0000019) (0.34)
g_{21}	0.02292 (1.38)	0.04542 (1.10)	-0.005452 (-0.33)
g_{22}	-0.002876 (-0.20)	0.04047 (1.21)	0.003858 (0.42)
g_{23}	-0.01585 (-1.69)*	-0.02815 (-0.82)	-0.0001102 (-0.01)
g_{24}	0.006351 (1.36)	0.03487 (2.10)	-0.001489 (-0.43)
g_{25}	0.00000251 (0.44)	-0.0001155 (-1.05)	-0.00000060 (-0.10)
g_{31}	0.003700 (0.22)	0.01631 (0.41)	-0.003909 (-0.24)
g_{32}	-0.004111 (-0.28)	0.01504 (0.46)	0.0005152 (0.06)

Table D-8 (Continued)

Estimated Coefficient	Group I	Group II	Group III
g_{33}	-0.002771 (-0.30)	-0.003362 (-0.10)	-0.0002197 (-0.03)
g_{34}	0.001361 (0.29)	0.01415 (0.85)	0.0002855 (0.08)
g_{35}	0.00000061 (0.11)	-0.00000809 (-0.73)	-0.00000199 (-0.35)
SSE	0.1442	0.05823	0.02016
SST	0.1532	0.1245	0.02536
R^2	.059	.532	.205

[1]The t-value associated with each coefficient value is reported in parentheses. All significance tests are two-tailed tests against the alternative that the true values of the coefficients are zero. A single asterisk (*) denotes significance at the 10 precent level; double asterisks (**), at the five percent level; and triple asterisks (***), at the one percent level. SSE is the regression error sum of squares; SST is the regression total sum of squares.

<u>the results of chapter 4 are not so much reflections of the differences between the two approaches as they are reflections of the powerful effects of untested restrictions.</u>

This conclusion is further supported when the symmetry restrictions are imposed. The separability restriction of the 3-good model is already so powerful that the additional symmetry restrictions involve little additional sacrifice of explanatory power for the 3-good model. Consequently, as indicated by the Chow test reported in table D-10, the symmetry restrictions cannot be rejected for the 3-good model. By contrast the symmetry restrictions are uniformly rejected for the 4-good model. The latter correspond to the regressions of tables D-7 and D-8. Those results indicate that the R^2 values remain quite high (above .65) for the restricted 3-good model but

Table D-9. Price and income elasticities: translog model, explicit homotheticity (aggregate, July-September)[1]

Three Good Model:

Group I (df=45)			
	P	I	B
P	-0.5715*** (-9.392)	-0.476*** (-8.85)	-0.0379 (-0.89)
I	-0.3176*** (-7.52)	-0.4882*** (-13.086)	-0.1867*** (-6.34)
B	-0.22460 (-1.053)	-0.2362 (-1.253)	-0.3233** (-2.168)

Group II (df=8)			
	P	I	B
P	-0.61368*** (-6.005)	-0.2793** (-2.17)	-0.2378** (-2.36)
I	-0.70037*** (-4.99)	-0.2595 (-1.46)	0.1492 (1.08)
B	0.1390 (0.2546)	-0.6844 (-0.996)	-0.3883 (-0.7213)

Group III (df=17)			
	P	I	B
P	-0.6365*** (-14.922)	-0.19093*** (-4.10)	-0.176*** (-4.77)
I	-0.582*** (-7.49)	-0.295*** (-3.477)	-0.155** (-2.30)
B	-0.8217*** (-3.625)	-0.1511 (-0.6106)	0.036 (0.184)

Four Good Model:

Group I (df=45)			
	P	I	B
P	0.4297 (0.8536)	-0.159 (-0.46)	0.007 (0.030)
I	0.5930 (1.14)	-0.1456 (-0.402)	-0.0637 (-0.27)
B	0.7002 (1.12)	0.0233 (0.05)	-0.414 (-1.49)

Group II (df=8)			
	P	I	B
P	-1.8179 (-1.089)	-1.775 (-0.77)	1.449 (0.940)
I	-1.1997 (-0.72)	-1.3557 (-0.572)	1.426 (0.92)
B	0.5067 (0.20)	1.1963 (0.35)	-0.582 (-0.2505)

Group III (df=17)			
	P	I	B
P	0.188 (0.5032)	-0.1798 (-0.19)	-0.00148 (-0.001)
I	0.3853 (0.99)	0.5241 (0.519)	-0.15924 (-0.43)
B	-0.0802 (-0.19)	0.2758 (0.26)	0.0706 (0.1814)

[1]The exact specification of the models are given in equation (D-6). The total number of observations (n) for each regression is given in table 2-3. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

deteriorate badly for the restricted 4-good model as an apparent result of the restrictions.

Nonetheless the elasticity estimates associated with these two restricted models are reported in table D-11. In general the elasticities appear quite high but their credibility is questionable for the reasons mentioned above.

Overall, the results of both this appendix and chapter 4 suggest that (aside from the unrestricted 4-good model) the intrinsically linear translog formulations are too restrictive--at least in the context of this data set. Although adequate resources were unavailable to complete nonlinear estimates during this study, it appears that a much fairer application of the translog model (and a much fairer test of the symmetry restrictions) would be to relax the explicit homotheticity restrictions by estimating a fully unrestricted 4-good model, i.e., the nonlinear version of the translog. Then symmetry could be tested in the same context following the method of Christensen et al. (1975). However, having said that about the general methodology of translog applications, it would still seem very unlikely that these Arizona data would, under any circumstances short of severe flogging (i.e., of the application of severely restrictive models), demonstrate significant responsiveness to the administered variations in <u>marginal</u> TOU prices. This statement is based on our analysis of the large number of alternative explicit demand function models reported here and other models not reported here. Yet it appears that, as a group, customers on the TOD rates did shift their TOD usage as reported in chapter 3.

There are several possible explanations for this apparently "flat" response surface, not the least of which is the comparatively complex experimental billing scheme detailed in the first footnote of chapter 2. Upon

Table D-10. Omnibus tests of the symmetry restrictions given explicit homotheticity (F-statistics)[1]

Group	F-statistics	
	3-good model	4-good model
Group I	1.708	10.163***
Group II	1.284	3.175*
Group III	0.053	2.378*

[1]Significance at the 10, 5, and 1 percent levels are denoted by the symbols *, **, and ***, respectively.

reviewing both that note and the customer education literature that was distributed to the experiment participants (Arizona Solar Energy Research Commission Final Report, Appendix B, 1977), one is tempted to conclude that the participants might have been more impressed by the available discount and its general responsiveness to the time pattern of prices than to the exact magnitude of the marginal rates. In any event it appears that much better estimates of TOD electricity demand response surfaces will be achieved using data from several of the other DOE Electric Utility Demonstration projects that involve both "cleaner" incentive and revenue neutralization schemes than did the Arizona project.

Table D-11. Price and income elasticities: translog model, explicit homotheticity and symmetry (aggregate, July-September)[1]

Three Good Model:

Group I (df=93)

	P	I	B
P	-0.546*** (-12.43)	-0.412*** (-11.67)	-0.042 (-0.84)
I	-0.376*** (-11.67)	-0.453*** (-11.56)	-0.171*** (-3.37)
B	-0.116 (-0.84)	-0.523*** (-3.37)	-0.360* (-1.73)

Group II (df=19)

	P	I	B
P	-0.572*** (-6.15)	-0.295*** (-3.89)	-0.133 (-1.24)
I	-0.492*** (-3.89)	-0.521*** (-3.06)	0.013 (0.06)
B	-0.548 (-1.24)	0.312 (0.06)	-0.484 (-0.71)

Group III (df=37)

	P	I	B
P	-0.638*** (-23.71)	-0.183*** (-7.77)	-0.179 (-5.36)
I	-0.577*** (-7.77)	-0.277*** (-2.65)	-0.146 (-1.14)
B	-0.822*** (-5.36)	-0.212 (-1.14)	0.034 (0.14)

Four Good Model:

Group I (df=141)

	P	I	B	Y
P	-0.112 (-0.18)	-0.406 (-1.11)	0.231 (0.90)	1.0
I	-0.392 (-1.11)	-0.628 (-1.50)	0.222 (1.01)	1.0
B	0.656 (0.90)	0.655 (1.01)	-0.500 (-0.75)	1.0

Group II (df=30)

	P	I	B	Y
P	-2.490* (-1.98)	-1.102 (-0.78)	0.661 (0.66)	1.0
I	-1.753 (-0.78)	-0.720 (-0.21)	0.837 (0.39)	1.0
B	2.445 (0.66)	1.947 (0.39)	-2.536 (-0.71)	1.0

Group III (df=57)

	P	I	B	Y
P	-0.205 (-0.75)	-0.132 (-0.51)	0.032 (0.18)	1.0
I	-0.422 (-0.51)	-0.343 (-0.15)	0.147 (0.17)	1.0
B	0.149 (0.18)	0.215 (0.17)	-0.005 (-0.005)	1.0

[1]The exact specifications of the models are given in equation (D-6). The total number of observations (n) for each regression is given in table 2-3. The symbols P, I, B, and Y denote peak, intermediate, and base periods and income, respectively. The parenthesized numbers are t-statistics and (two-tailed) significance tests at the 10, 5, and 1 percent levels are denoted by *, **, and *** symbols, respectively.

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